KN 8036

PATENT COOPERATION TREATY

1998 -10- 01

PCT

INTERNATIONAL PRELIMINARY EXAMINATION REPORT

(PCT Article 36 and Rule 70)

Applicant's or agent's file reference P 97-250/ST/PA	FOR FURTHER ACTION	See Notification of Transmittal of International Preliminary Examination Report (Form PCT/IPEA/416)
International application No. PCT/SE97/00905	International filing date *(day/month/year)* 27.05.1997	Priority date *(day/month/year)* 29.05.1996
International Patent Classification (IPC) or national classification and IPC6 H02K 3/46, H02K 15/005		
Applicant ASEA BROWN BOVERI AB et al		

1. This international preliminary examination report has been prepared by this International Preliminary Examining Authority and is transmitted to the applicant according to Article 36.

2. This REPORT consists of a total of 4 sheets, including this cover sheet.

   ☒ This report is also accompanied by ANNEXES, i.e., sheets of the description, claims and/or drawings which have been amended and are the basis for this report and/or sheets containing rectifications made before this Authority (see Rule 70.16 and Section 607 of the Administrative Instructions under the PCT).

   These annexes consist of a total of 4 sheets.

3. This report contains indications relating to the following items:

   - I ☒ Basis of the report
   - II ☐ Priority
   - III ☐ Non-establishment of opinion with regard to novelty, inventive step and industrial applicability
   - IV ☐ Lack of unity of invention
   - V ☒ Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement
   - VI ☐ Certain documents cited
   - VII ☐ Certain defects in the international application
   - VIII ☐ Certain observations on the international application

Date of submission of the demand	Date of completion of this report
29.12.1997	21.09.1998
Name and mailing address of the IPEA/SE Patent- och registreringsverket Box 5055 S-102 42 STOCKHOLM Telex 17978 PATOREG-S Facsimile No. 08-667 72 88	Authorized officer Håkan Sandh Telephone No. 08-782 25 00

Form PCT/IPEA/409 (cover sheet) (January 1994)

INTERNATIONAL PRELIMINARY EXAMINATION REPORT

International application No.
PCT/SE97/00905

V. Resoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

1. Statement

Novelty (N)	Claims	1-19	YES
	Claims		NO
Inventive step (IS)	Claims	1-19	YES
	Claims		NO
Industrial applicability (IA)	Claims	1-19	YES
	Claims		NO

2. Citations and explanations

The invention relates to a stator winding in a rotating electrical machine and a rotating electrical machine with a magnetic circuit comprising a winding for high voltage. Said winding is provided with an insulation system comprising two semiconducting layers with solid insulation in-between.

Documents cited in the International Search Report:

(A) US A 5036165
(B) DE A 2155371
(C) DE A 3028777
(D) GB A 2070470
(E) GB A 2106721
(F) WO A 9321681
(G) US A 4307311
(H) US A 4918347
(I) Patent abstract of JP A 59-159642

(A) describes a cable provided with two semiconducting layers with insulation there between.The semiconducting layers include pyrolized organic material and glass fibre. In this document it is suggested that the invented semiconducting layer can be applied to insulated conductors such as a winding in a dynamo-electric machine.

(B-I) relates to general prior art.

The claimed invention differs from the cited art in that the winding of the machine is provided with an insulation system comprising two semiconducting layers with solid insulation in-between.

.../...

Supplemental Box
(To be used when the space in any of the preceding boxes is not sufficient)

Continuation of: V

Even though it is suggested in document A to apply a semiconducting layer to a winding in a dynamo-electric machine there is no specific indication of using the disclosed cable in a dynamo-electric machine. Further investigating US 4853565, incorporated by reference in document A, the skilled person will find it evident that the invented semiconducting layer is intended to be used on a conventional winding in a machine or in a cable. There is no proposal to use the cable with the insulating system as a winding in an electric machine. Nor can it be considered obvious to a person skilled in the art to use such a cable in a dynamo-electric machine since at the time of the invention it was not known to use a cable with solid insulation as a winding in an electrical machine and there is no teaching in the prior art as a whole that would lead the skilled person to the claimed invention.

Accordingly, the invention claimed is novel and involves an inventive step. The invention is industrially applicable.

5/19/1

003369437
WPI Acc No: 82-M7470E/198239
HV winding anti-sparking layer for electrical machines - has semiconductor layer having number of electrical polarising contacts to windings (SE 30.8.82)
Patent Assignee: ELIN-UNION AG (ELIU)
Inventor: VONES K
Number of Countries: 005 Number of Patents: 006
Patent Family:

Patent No	Kind	Date	Applicat No	Kind	Date	Main IPC	Week
FR 2499306	A	19820806					198239 B
SE 8200303	A	19820830					198237
DE 3200366	A	19821209					198250
AT 8100415	A	19841115					198450
CH 657482	A	19860829					198638
SE 453236	B	19880118					198805

Priority Applications (No Type Date): AT 81415 A 19810130
Patent Details:

Patent	Kind	Lan	Pg	Filing Notes	Application	Patent
FR 2499306	A		7			

Abstract (Basic): FR 2499306 A

A layer of semiconductor (2), either deposited or in band form, surrounds an inner insulation layer (8) adjacent to the windings (6). The semiconductor makes ohmic contact with a number of metal polarising terminals (3,4) which are electrically connected to the windings. Potential differences within the semiconductor layer between polarisation terminals are minimised.

The anti-sparking semiconductor layer is deposited directly on the network of polarising connections. The windings (5) are wrapped around insulating formers (6) and the whole unit has a thick outer layer of insulation (8). Sparking at the cavities formed in the event of parts of insulation becoming detached from the winding is eliminated.

1/1

Title Terms: HV; WIND; ANTI; SPARK; LAYER; ELECTRIC; MACHINE; SEMICONDUCTOR ; LAYER; NUMBER; ELECTRIC; POLARISE; CONTACT; WIND
Derwent Class: V02; V06; X11; X12
International Patent Class (Additional): H01F-015/04; H01F-027/36; H02K-003/40
File Segment: EPI
Manual Codes (EPI/S-X): V02-G02B; V06-M08; X11-J02B; X12-C01

PATENT COOPERATION TREATY

From the INTERNATIONAL BUREAU

PCT

NOTIFICATION OF ELECTION

(PCT Rule 61.2)

To:

United States Patent and Trademark Office
(Box PCT)
Crystal Plaza 2
Washington, DC 20231
ETATS-UNIS D'AMERIQUE

in its capacity as elected Office

Date of mailing (day/month/year) 29 January 1998 (29.01.98)	
International application No. PCT/SE97/00905	**Applicant's or agent's file reference** P 97-250/St
International filing date (day/month/year) 27 May 1997 (27.05.97)	**Priority date** (day/month/year) 29 May 1996 (29.05.96)
Applicant LEIJON, Mats et al	

1. The designated Office is hereby notified of its election made:

[X] in the demand filed with the International Preliminary Examining Authority on:

29 December 1997 (29.12.97)

[ ] in a notice effecting later election filed with the International Bureau on:

2. The election [X] was

[ ] was not

made before the expiration of 19 months from the priority date or, where Rule 32 applies, within the time limit under Rule 32.2(b).

The International Bureau of WIPO
34, chemin des Colombettes
1211 Geneva 20, Switzerland

Facsimile No.: (41-22) 740.14.35

Authorized officer

Céline Faust

Telephone No.: (41-22) 338.83.38

PATENT COOPERATION TREATY

PCT

INTERNATIONAL PRELIMINARY EXAMINATION REPORT

(PCT Article 36 and Rule 70)

Applicant's or agent's file reference P 97-250/ST/PA	**FOR FURTHER ACTION**	See Notification of Transmittal of International Preliminary Examination Report (Form PCT/IPEA/416)
International application No. PCT/SE97/00905	International filing date *(day/month/year)* 27.05.1997	Priority date *(day/month/year)* 29.05.1996
International Patent Classification (IPC) or national classification and IPC6 H02K 3/46, H02K 15/005		
Applicant ASEA BROWN BOVERI AB et al		

1. This international preliminary examination report has been prepared by this International Preliminary Examining Authority and is transmitted to the applicant according to Article 36.

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   ☒ This report is also accompanied by ANNEXES, i.e., sheets of the description, claims and/or drawings which have been amended and are the basis for this report and/or sheets containing rectifications made before this Authority (see Rule 70.16 and Section 607 of the Administrative Instructions under the PCT).

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3. This report contains indications relating to the following items:

   - I ☒ Basis of the report
   - II ☐ Priority
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   - IV ☐ Lack of unity of invention
   - V ☒ Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement
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Date of submission of the demand	Date of completion of this report
29.12.1997	21.09.1998
Name and mailing address of the IPEA/SE Patent- och registreringsverket Box 5055 S-102 42 STOCKHOLM Telex 17978 PATOREG-S Facsimile No. 08-667 72 88	Authorized officer Håkan Sandh Telephone No. 08-782 25 00

Form PCT/IPEA/409 (cover sheet) (January 1994)

INTERNATIONAL PRELIMINARY EXAMINATION REPORT

International application No.
PCT/SE97/00905

I. Basis of the report

1. This report has been drawn on the basis of *(Replacement sheets which have been furnished to the receiving Office in response to an invitation under Article 14 are referred to in this report as "originally filed" and are not annexed to the report since they do not contain amendments.)*:

☒ the international application as originally filed.

☐ the description, pages 1-7 , as originally filed,
pages _____ , filed with the demand,
pages _____ , filed with the letter of _____ ,
pages _____ , filed with the letter of _____ .

☒ the claims, Nos. _____ , as originally filed,
Nos. _____ , as amended under Article 19,
Nos. _____ , filed with the demand,
Nos. 1-19 , filed with the letter of 31.08.1998 ,
Nos. _____ , filed with the letter of _____ .

☒ the drawings, ~~sheets~~/fig 1-8 , as originally filed,
~~sheets~~/fig _____ , filed with the demand
~~sheets~~/fig _____ , filed with the letter of _____ ,
~~sheets~~/fig _____ , filed with the letter of _____ .

2. The amendments have resulted in the cancellation of:

☐ the description, pages _____
☐ the claims, Nos. _____
☐ the drawings, ~~sheets~~/fig _____

3. ☐ This report has been established as if (some of) the amendments had not been made, since they have been considered to go beyond the disclosure as filed, as indicated in the supplemental Box (Rule 70.2(c)).

4. Additional observations, if necessary:

RECO COPY

PCT

REQUEST

The undersigned requests that the present international application be processed according to the Patent Cooperation Treaty.

For receiving Office use only

International Application No. PCT, SE 97/00905

International Filing Date 27-05-1997

The Swedish Patent Office
PCT International Application

Name of receiving Office and "PCT International Application"

Applicant's or agent's file reference *(if desired) (12 characters maximum)* P 97-250/St /uh

Box No. I TITLE OF INVENTION

A DEVICE IN THE STATOR OF A ROTATING ELECTRIC MACHINE AND SUCH A MACHINE

Box No. II APPLICANT

Name and address: *(Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country. The country of the address indicated in this Box is the applicant's State (i.e. country) of residence if no State of residence is indicated below.)*

Asea Brown Boveri AB

S-721 83 VÄSTERÅS
Sweden

☐ This person is also inventor.

Telephone No.

Facsimile No.

Teleprinter No.

State *(i.e. country)* of nationality: SE

State *(i.e. country)* of residence: SE

This person is applicant for the purposes of: ☐ all designated States ☒ all designated States except the United States of America ☐ the United States of America only ☐ the States indicated in the Supplemental Box

Box No. III FURTHER APPLICANT(S) AND/OR (FURTHER) INVENTOR(S)

Name and address: *(Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country. The country of the address indicated in this Box is the applicant's State (i.e. country) of residence if no State of residence is indicated below.)*

LEIJON, Mats

Hyvlargatan 5

S-723 35 VÄSTERÅS
Sweden

This person is:

☐ applicant only

☒ applicant and inventor

☐ inventor only *(If this check-box is marked, do not fill in below.)*

State *(i.e. country)* of nationality: SE

State *(i.e. country)* of residence: SE

This person is applicant for the purposes of: ☐ all designated States ☐ all designated States except the United States of America ☒ the United States of America only ☐ the States indicated in the Supplemental Box

☒ Further applicants and/or (further) inventors are indicated on a continuation sheet.

Box No. IV AGENT OR COMMON REPRESENTATIVE; OR ADDRESS FOR CORRESPONDENCE

The person identified below is hereby/has been appointed to act on behalf of the applicant(s) before the competent International Authorities as: ☒ agent ☐ common representative

Name and address: *(Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country.)*

L.A.GROTH & Co.KB
STOLT, Lars C. et al.
Box 6107
S-102 32 STOCKHOLM
Sweden

Telephone No. +46 - 8 - 729 91 00

Facsimile No. +46 - 8 - 31 67 67

Teleprinter No.

☐ Mark this check-box where no agent or common representative is/has been appointed and the space above is used instead to indicate a special address to which correspondence should be sent.

Continuation of Box No. III FURTHER APPLICANTS AND/OR (FURTHER) INVENTORS

If none of the following sub-boxes is used, this sheet is not to be included in the request.

Name and address: *(Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country. The country of the address indicated in this Box is the applicant's State (i.e. country) of residence if no State of residence is indicated below.)*

HÖLLELAND, Mons
Fornforskargatan 52

S-723 53 VÄSTERÅS
Sweden

This person is:
- ☐ applicant only
- ☒ applicant and inventor
- ☐ inventor only *(If this check-box is marked, do not fill in below.)*

State *(i.e. country)* of nationality: SE

State *(i.e. country)* of residence: SE

This person is applicant for the purposes of:
- ☐ all designated States
- ☐ all designated States except the United States of America
- ☒ the United States of America only
- ☐ the States indicated in the Supplemental Box

Name and address: *(Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country. The country of the address indicated in this Box is the applicant's State (i.e. country) of residence if no State of residence is indicated below.)*

KALLDIN, Hans-Olof
Grenadjärgatan 9

S-723 46 VÄSTERÅS
Sweden

This person is:
- ☐ applicant only
- ☒ applicant and inventor
- ☐ inventor only *(If this check-box is marked, do not fill in below.)*

State *(i.e. country)* of nationality: SE

State *(i.e. country)* of residence: SE

This person is applicant for the purposes of:
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- ☐ the States indicated in the Supplemental Box

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TEMPLIN, Peter
Dybecksgatan 4 B

S-731 40 KÖPING
Sweden

This person is:
- ☐ applicant only
- ☒ applicant and inventor
- ☐ inventor only *(If this check-box is marked, do not fill in below.)*

State *(i.e. country)* of nationality: SE

State *(i.e. country)* of residence: SE

This person is applicant for the purposes of:
- ☐ all designated States
- ☐ all designated States except the United States of America
- ☒ the United States of America only
- ☐ the States indicated in the Supplemental Box

Name and address: *(Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country. The country of the address indicated in this Box is the applicant's State (i.e. country) of residence if no State of residence is indicated below.)*

ROTHMAN, Bengt
Profilgatan 16

S-723 36 VÄSTERÅS
Sweden

This person is:
- ☐ applicant only
- ☒ applicant and inventor
- ☐ inventor only *(If this check-box is marked, do not fill in below.)*

State *(i.e. country)* of nationality: SE

State *(i.e. country)* of residence: SE

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Continuation of Box No. III FURTHER APPLICANTS AND/OR (FURTHER) INVENTORS

If none of the following sub-boxes is used, this sheet is not to be included in the request.

Name and address: *(Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country. The country of the address indicated in this Box is the applicant's State (i.e. country) of residence if no State of residence is indicated below.)*

IVARSON, Claes
Barkarö Bygatan 221

S-725 91 VÄSTERÅS
Sweden

This person is:
- ☐ applicant only
- ☒ applicant and inventor
- ☐ inventor only *(If this check-box is marked, do not fill in below.)*

State *(i.e. country)* of nationality: SE

State *(i.e. country)* of residence: SE

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Name and address: *(Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country. The country of the address indicated in this Box is the applicant's State (i.e. country) of residence if no State of residence is indicated below.)*

GÖRAN, Bengt
Vales väg 13

S-723 55 VÄSTERÅS
Sweden

This person is:
- ☐ applicant only
- ☒ applicant and inventor
- ☐ inventor only *(If this check-box is marked, do not fill in below.)*

State *(i.e. country)* of nationality: Sweden

State *(i.e. country)* of residence: Sweden

This person is applicant for the purposes of:
- ☐ all designated States
- ☐ all designated States except the United States of America
- ☒ the United States of America only
- ☐ the States indicated in the Supplemental Box

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This person is:
- ☐ applicant only
- ☐ applicant and inventor
- ☐ inventor only *(If this check-box is marked, do not fill in below.)*

State *(i.e. country)* of nationality:

State *(i.e. country)* of residence:

This person is applicant for the purposes of:
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- ☐ inventor only *(If this check-box is marked, do not fill in below.)*

State *(i.e. country)* of nationality:

State *(i.e. country)* of residence:

This person is applicant for the purposes of:
- ☐ all designated States
- ☐ all designated States except the United States of America
- ☐ the United States of America only
- ☐ the States indicated in the Supplemental Box

☐ Further applicants and/or (further) inventors are indicated on another continuation sheet.

Box No.V DESIGNATION OF STATES

The following designations are hereby made under Rule 4.9(a) *(mark the applicable check-boxes; at least one must be marked)*:

Regional Patent

- ☒ AP **ARIPO Patent:** KE Kenya, LS Lesotho, MW Malawi, SD Sudan, SZ Swaziland, UG Uganda, and any other State which is a Contracting State of the Harare Protocol and of the PCT
- ☒ EA **Eurasian Patent:** AM Armenia, AZ Azerbaijan, BY Belarus, KG Kyrgyzstan, KZ Kazakstan, MD Republic of Moldova, RU Russian Federation, TJ Tajikistan, TM Turkmenistan, and any other State which is a Contracting State of the Eurasian Patent Convention and of the PCT
- ☒ EP **European Patent:** AT Austria, BE Belgium, CH and LI Switzerland and Liechtenstein, DE Germany, DK Denmark, ES Spain, FI Finland, FR France, GB United Kingdom, GR Greece, IE Ireland, IT Italy, LU Luxembourg, MC Monaco, NL Netherlands, PT Portugal, SE Sweden, and any other State which is a Contracting State of the European Patent Convention and of the PCT
- ☒ OA **OAPI Patent:** BF Burkina Faso, BJ Benin, CF Central African Republic, CG Congo, CI Côte d'Ivoire, CM Cameroon, GA Gabon, GN Guinea, ML Mali, MR Mauritania, NE Niger, SN Senegal, TD Chad, TG Togo, and any other State which is a member State of OAPI and a Contracting State of the PCT *(if other kind of protection or treatment desired, specify on dotted line)* . . . . . .

National Patent *(if other kind of protection or treatment desired, specify on dotted line)*:

- ☒ AL Albania . . . . . .
- ☒ AM Armenia . . . . . .
- ☒ AT Austria . . . . . .
- ☒ AU Australia . . . . . .
- ☒ AZ Azerbaijan
- ☒ BA Bosnia and Herzegovina
- ☒ BB Barbados
- ☒ BG Bulgaria . . . . . .
- ☒ BR Brazil . . . . . .
- ☒ BY Belarus
- ☒ CA Canada
- ☒ CH and LI Switzerland and Liechtenstein
- ☒ CN China . . . . . .
- ☒ CU Cuba . . . . . .
- ☒ CZ Czech Republic and utility model . . . . .
- ☒ DE Germany . and. utility. model. . . . . .
- ☒ DK Denmark . and. utility. model. . . . . .
- ☒ EE Estonia . . . . . .
- ☒ ES Spain . . . . . .
- ☒ FI Finland . . and utility model . . . . . .
- ☒ GB United Kingdom
- ☒ GE Georgia . . . . . .
- ☒ HU Hungary . . . . . .
- ☒ IL Israel . . . . . .
- ☒ IS Iceland
- ☒ JP Japan . . . . . .
- ☒ KE Kenya . . . . . .
- ☒ KG Kyrgyzstan . . . . . .
- ☒ KP Democratic People's Republic of Korea . . . . . .
- ☒ KR Republic of Korea . . . . . .
- ☒ KZ Kazakstan . . . . . .
- ☒ LC Saint Lucia
- ☒ LK Sri Lanka
- ☒ LR Liberia
- ☒ LS Lesotho . . . . . .
- ☒ LT Lithuania
- ☒ LU Luxembourg . . . . . .
- ☒ LV Latvia
- ☒ MD Republic of Moldova . . . . . .
- ☒ MG Madagascar . . . . . .
- ☒ MK The former Yugoslav Republic of Macedonia . . . . . .
- ☒ MN Mongolia
- ☒ MW Malawi . . . . . .
- ☒ MX Mexico . . . . . .
- ☒ NO Norway
- ☒ NZ New Zealand . . . . . .
- ☒ PL Poland . . . . . .
- ☒ PT Portugal . . . . . .
- ☒ RO Romania
- ☒ RU Russian Federation . . . . . .
- ☒ SD Sudan
- ☒ SE Sweden
- ☒ SG Singapore
- ☒ SI Slovenia . . . . . .
- ☒ SK Slovakia . . . . . .
- ☒ TJ Tajikistan . . . . . .
- ☒ TM Turkmenistan . . . . . .
- ☒ TR Turkey . . . . . .
- ☒ TT Trinidad and Tobago . . . . . .
- ☒ UA Ukraine . . . . . .
- ☒ UG Uganda . . . . . .
- ☒ US United States of America . . . . . .
- ☒ UZ Uzbekistan . . . . . .
- ☒ VN Viet Nam . . . . . .

Check-boxes reserved for designating States (for the purposes of a national patent) which have become party to the PCT after issuance of this sheet:

- ☒ YU Jugoslavien (fr. 1997-02-01)
- ☒ GH Ghana (AP) (fr. 1997-02-26)
- ☐ . . . . . .
- ☐ . . . . . .

In addition to the designations made above, the applicant also makes under Rule 4.9(b) all designations which would be permitted under the PCT except the designation(s) of _____.

The applicant declares that those additional designations are subject to confirmation and that any designation which is not confirmed before the expiration of 15 months from the priority date is to be regarded as withdrawn by the applicant at the expiration of that time limit. *(Confirmation of a designation consists of the filing of a notice specifying that designation and the payment of the designation and confirmation fees. Confirmation must reach the receiving Office within the 15-month time limit.)*

Box No. VI PRIORITY CLAIM Further priority claims are indicated in the Supplemental Box ☐

The priority of the following earlier application(s) is hereby claimed:

Country (in which, or for which, the application was filed)	Filing Date (day/month/year)	Application No.	Office of filing (only for regional or international application)
item (1) Sweden	29 May 1996 (29.05.1996)	9602079-7	
item (2) Sweden	29 May 1996 (29.05.1996)	9602094-6	
item (3) Sweden	03 February 1997 (03.02.1997)	9700356-0	

Mark the following check-box if the certified copy of the earlier application is to be issued by the Office which for the purposes of the present international application is the receiving Office (a fee may be required):

☒ The receiving Office is hereby requested to prepare and transmit to the International Bureau a certified copy of the earlier application(s) identified above as item(s): (1), (2), (3), ____

Box No. VII INTERNATIONAL SEARCHING AUTHORITY

Choice of International Searching Authority (ISA) *(If two or more International Searching Authorities are competent to carry out the international search, indicate the Authority chosen; the two-letter code may be used):* ISA / SE

Earlier search *Fill in where a search (international, international-type or other) by the International Searching Authority has already been carried out or requested and the Authority is now requested to base the international search, to the extent possible, on the results of that earlier search. Identify such search or request either by reference to the relevant application (or the translation thereof) or by reference to the search request:*

Country (or regional Office):	Date (day/month/year):	Number:
SE	29 May 1996	SE 96/00648, SE96/00636, SE97/00116

RO/SE

Box No. VIII CHECK LIST

This international application contains the following number of sheets:

1. request	:	5 sheets
2. description	:	7 sheets
3. claims	:	3 sheets
4. abstract	:	1 sheets
5. drawings	:	6 sheets
Total	:	22 sheets

This international application is accompanied by the item(s) marked below:

1. ☐ separate signed power of attorney
2. ☐ copy of general power of attorney
3. ☐ statement explaining lack of signature
4. ☐ priority document(s) *identified in Box No. VI as item(s):*
5. ☐ fee calculation sheet
6. ☐ separate indications concerning deposited microorganisms
7. ☐ nucleotide and/or amino acid sequence listing (diskette)
8. ☒ other *(specify)*: Copy of Off.Action and ITS Report

Figure No. 2 of the drawings (if any) should accompany the abstract when it is published.

Box No. IX SIGNATURE OF APPLICANT OR AGENT

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L.A.GROTH & Co.KB

Lars C. Stolt

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ANORDNING I STATORN HOS EN ELEKTRISK MASKIN SAMT SÅDAN MASKIN

Föreliggande uppfinning hänför sig till området för roterande elektriska maskiner, exempelvis synkronmaskiner, men även dubbelmatade maskiner, tillämpningar i asynkrona strömriktarkaskader, ytterpolmaskiner och synkronflödesmaskiner, och är avsedd att användas vid höga spänningar, varmed här avses elektriska spänningar, som i första hand överstiger 10 kV. Ett typiskt arbetsområde för en anordning enligt uppfinningen kan vara 36 - 800 kV.

Uppfinningen avser en statorlindning i en roterande elektrisk maskin av i patentkravets 1 ingress angivet slag.

Genom att i enligt uppfinningen maskinens statorlindning utgöres av högspända isolerade elektriska ledare, i det följande benämnda kablar, med fast isolation av likartat utförande som kablar för överföring av elkraft (exempelvis s.k. PEX-kablar) kan maskinens spänning höjas till sådana nivåer att den kan direktanslutas till kraftnätet utan mellanliggande transformator. Dessa spänningsnivåer, som uppgår till nätets nivå, kan vara av inom området 130-400 kV, och upp till 800 kV eller högre. Därigenom kan upptransformatorn och en högströmsbrytare elimineras, vilket ger en lägre total anläggningskostnad.

Det är känt att tillverkningen av härvor för roterande maskiner kan ske till spänningsområdet 10 - 20 kV.

Försök att utveckla generatorn för högre spän-ningar än så har dock pågått sedan länge. Detta framgår bl.a. av "Electrical World", Oktober 15, 1932, sid. 524-525. Där beskrivs hur en av Parson konstruerad generator 1929 utfördes för 33 kV, och vidare beskrivs en generator i Langerbrugge i Belgien som gav en spänning på 36 kV. Ehuru i artikeln även spekuleras över möjligheten att gå vidare upp i spänningsnivåer avstannade dock utvecklingen av de idéer dessa generatorer byggde på. Detta berodde framförallt på tillkortakommanden med isolationssystemet, där man utnyttjade lackimpregnerade lager av glimmerfolium och papper i flera separata skikt.

I en rapport från Electric Power Research Institute, EPRI, EL-3391 från april 1984 redovisas en genom-gång av generator-idéer för att åstadkomma högre spänning hos en elektrisk generator i syfte att kunna ansluta en sådan till ett kraftnät utan mellanliggande transformator. En sådan lösning bedömdes av utredningen ge goda effektivitetsvinster och stora ekonomiska fördelar. Huvudanledningen till att man 1984 bedömde det möjligt att börja avveckla generatorer för direktanslutning till kraftnät var att man då hade tagit fram en supraledande rotor. Den stora magnetiseringskapaciteten hos det supraledande fältet gör det möjligt att använda luft-gapslindning med tillräcklig tjocklek för att stå emot de elektriska påkänningarna.

Genom att kombinera den enligt projektet mest lovande idén att konstruera en magnetkrets med lindning, s.k. "monolithe cylinder armature", en idé där två cylindrar av ledare är inneslutna i tre cylindrar av isolation och hela strukturen fästes vid en järnkärna utan tänder, gjordes bedömningen att en roterande elektrisk maskin för högspänning skulle kunna direktanslutas till ett kraftnät. Lösningen innebar att huvudisolationen måste göras tillräckligt tjock för att klara potentialer nät-mot-nät och nät-mot-jord. Uppenbara nackdelar med den föreslagna lösningen är att den, förutom en supraledande rotor, kräver en mycket tjock isolering, vilket ökar maskinstorleken. Härvändarna måste isoleras och kylas med olja eller freoner för att styra de stora elektriska fälten i ändarna. Hela maskinen måste vara hermetiskt innesluten för att förhindra det flytande di-elektrikum att ta upp fukt från atmosfären.

Normalt utföres alla större generatorer med två-skiktslindning och lika stora härvor. Varje härva placeras med den ena sidan i det ena skiktet och den andra sidan i det andra skiktet. Detta innebär att samtliga härvor korsar varandra i härvändorna. I högspänningsmaskiner är de spår i statorn i vilka härvorna förlägges betydligt djupare med typiskt 10-12 eller upp till 18 och i vissa fall ännu fler

lindningsskikt. Därigenom blir antalet härvändor stort med många korsningar, vilket försvårar lindningsarbetet och även gör att härvändorna kan skjuta ut i luftgapet mellan statorn och rotorn. Ett annat problem är en större risk för nötning som uppstår vid alla korsningspunkter mellan härvorna.

Syftet med föreliggande uppfinning är att lösa detta problem med de stora härvändspaketen och minimera antalet korsningar mellan lindningshärvorna. Detta syfte har uppnåtts genom att statorlindningen enligt uppfinningen erhållit de i patentkraven angivna kännetecknen.

Uppfinningen är i första hand tänkt att användas vid och dess fördelar blir särskilt framträdande med en högspänningskabel av det slag som är uppbyggd av en kärna med ett antal kardeler, ett kärnan omslutande inre halvledande skikt, ett det inre halvledande skiktet omslutande isolerande skikt och ett det isolerande skiktet omslutande yttre halvledande skikt. Speciellt avses en dylik kabel med en diameter i intervallet 20 - 200 mm och en ledningsarea i intervallet 80 - 3000 mm^2. Dylika applikationer av uppfin-ningen utgör sålunda föredragna utföringsformer av densamma.

Uppfinningen beskrives nedan närmare med hänvisning till bifogade ritningar, på vilka

fig. 1 visar ett tvärsnitt genom en kabel, använd vid uppfinningen,

fig. 2 visar en del av den ena änden av en stator, från vars ändyta utskjuter en mängd härvändar, av vilka endast ett fåtal har utritats,

fig. 3 i ett radiellt snitt visar ena halvan av en växelströmsgenerator med en statorlindning enligt uppfinningen,

fig. 4 visar ett schema över lindningen enligt en utföringsform av uppfinningen,

fig. 5 visar ett schema över lindningen enligt en andra utföringsform av uppfinningen,

fig. 6 visar en sektor av en statorplåt för en lindning enligt uppfinningen,

fig. 7 visar ett schema över lindningen enligt en tredje utföringsform av uppfinningen och

fig. 8 visar ett härvändspaket radiellt från luftgapet med en lindning enligt uppfinningen.

I fig. 1 visas en tvärsnittsvy av en kabel 101 använd vid föreliggande uppfinning. Kabeln 101 innefattar en av ett antal kardeler bestående ledare 102 med cirkulärt tvärsnitt och av exempelvis koppar. Denna ledare 102 är anordnad i mitten av kabeln 101. Runt ledaren 102 finns ett första halvledande skikt 103. Runt det första halvledande skiktet 103 finns ett isolationsskikt 104, t.ex. PEX-isolation. Runt isolationsskiktet 104 finns ett andra halv-ledande skikt 105. I detta fall innefattar kabeln således ej det yttre skyddshölje som normalt omger en dylik kabel vid kraftdistribution.

I fig. 3 ses i ett diametralt snitt ena halvan av en högspänningsgenerator med en stator 106, en rotor 107 och däremellan ett luftgap 108. I fig. 2 ses statorns inre, mot luftgapet 108 vettande yta 109. Statorn 106 har inåtriktade statortänder 110, som mellan sig avgränsar radiella spår 111 för upptagande av lindningens kablar 101. Genom de djupa spåren 111, som i det visade exemplet har plats för tolv kablar i varsin utvidgning 112 i spåren 111, bildar lindningen ett stort antal lager. Här avses med lager av lindningen lager på olika radiella avstånd från statorns centrumaxel. Med skikt däremot avses skikt av lindningen på olika axiella avstånd från statorns ändytor.

Av fig. 2 framgår hur kabeln 101 bildar härvor 113, som sträcker sig fram och tillbaka axiellt genom statorn 106 och utanför statorns ändytor 114 bildar bågformiga härvändar. En härva består således av ett varv av kabeln genom statorn. En härvgrupp omfattar lindningen för en fas. Den del av en härvgrupp som ligger i ett och samma lindningslager och vars härvändar ligger i olika skikt betecknas här härvgruppsdel.

Till skillnad mot tidigare kända flerskikts statorlindningar är härvorna 113 enligt uppfinningen så anordnade

att de inte korsar varandra inom samma härvgruppsdel. I fig. 2 ses en gruppdel om i detta fall fyra härvor 113a, 113b, 113c och 113d så anordnade att de ligger axiellt, den ena utanför den andra och med väsentligen sammanfallande centra. Genom att härvan 113a har större diameter än härvan 113b, som i sin tur har större diameter än härvan 113c, som i sin tur har större diameter än härvan 113d, korsar eller berör dessa härvor inte varandra. Detta innebär att det antal spår 111 som respektive härva överbryggar innan den skjuter ned i statorn igen varierar inom gruppdelen. Det vill säga att härvan 113d överbryggar minsta antalet spår och härvan 113a största antalet spår.

Lindningen sker vidare så, att kabeln i härvan vid övergång från det första spåret i den ena riktningen till det andra spåret i motsatt riktning byter position i spåret till närmast utanförliggande lindningslager. Detsamma sker vid återgång till det första spåret. Då alla positioner i de två spåren är fyllda, bildar härvorna en formation, som påminner om en från sidorna hoptryckt skruvlinjeform från luftgapet 108 mot statorryggen 115. Därefter övergår kabeln till närmast liggande spår för att bilda nästa härva, innanför eller utanför, i samma formation.

I fig. 4 ses ett schema över hur lindningen av en kabel U1 sker. I fig. 3 har spåren 111 och positionerna i dessa numrerats på motsvarande sätt som i fig. 4. Till skill-nad mot exemplet i fig. 2 omfattar varje härvgruppsdel här tre i stället för fyra härvor. Enligt fig. 4 utgår kabeln U1 från position 1 i spår 3 för att i spår 9 gå in i position 2 och sedan vid tillbakagång till spår 3 gå in i position 3 och sedan i position 4 i spår 9 osv. Detta fortfar tills samtliga positioner i spåren 3 och 9 har upptagits, varvid de sålunda bildade härvorna tillsammans bildar ovan nämnda formation från luftgapet 108 mot statorryggen 115. Som framgår, över-bryggar varje härvända 9-3 = 6 spår. Lindningen fortsätter nu genom uppbyggnad av en större utanförliggande härva i varje varv i formationen, genom att kabeln ledes till position 1 i spår 2

och därifrån till position 2 i spår 10 och tillbaka till position 3 i spår 2 osv. tills position 10 i spår 10 fyllts. Här överbryggar härvändorna 10-2 = 8 spår, vilket gör att dessa senare härvor kommer att ligga utanför de tidigare härvorna med väsentligen sammanfallande centra. Den tredje härvan i denna gruppdel bildas genom att kabeln övergår till position 1 i spår 1 och därifrån till position 2 i spår 11 och sedan till position 3 i spår 1 och position 4 i spår 11 osv. I detta fall överbryggar härvändorna 11-1 = 10 spår, och härvorna är alltså de största i gruppdelen och ligger ytterst i skruvlinjen. Den beskrivna härvgruppen bildar lindningen för en fas i generatorn. De övriga faserna bildas på likartat sätt.

I fig. 5 visas en andra utföringsform av lindningen enligt uppfinningen. Till skillnad mot utföringsformen enligt fig. 4 lindas positionerna 1 och 2 klart i spåren 4 och 11, 3 och 12 samt 1 och 14, innan man övergår till och fort-sätter med positionerna 3 och 4 i samma spår, varpå man fort-sätter med dessa fyra positioner i ytterligare spår. Schemat visar lindningarna av en fas i en trefaslindning med fyra härvor per spår och fyra spår per pol och fas.

Antalet härvor i varje härvgruppsdel är i de två beskrivna lindningsvarianterna tre respektive fyra. Emeller-tid är uppfinningen inte begränsad till dessa antal, utan antalet kan vara alltifrån två till över tio.

I fig. 6 - 8 visas en tredje utföringsform av lind-ningen enligt uppfinningen. Som framgår av fig. 6 har posi-tionerna i spåren omkastats gentemot fig. 3 - 5 och är num-rerade radiellt utifrån och in. Som framgår av fig. 8 är härvgruppsdelarna så inbördes anordnade i omkretsled att varannan härvgruppsdel på sin väg till ett radiellt yttre lager ligger radiellt innanför nästföjande härvgruppsdel och varannan härvgruppsdel radiellt utanför nästföljande härvgruppsdel. Sålunda går härvgruppsdelarna 116 på sin väg från position 1 i fyra intilliggande spår 111 radiellt innanför respektive nästföljande härvgruppsdel 117 på sin väg

mot position 2 i fyra spår 111 under överbryggande av sju spår, medan härvgruppsdelarna 117 går radiellt utanför respektive nästföljande härvgruppsdel 116. Genom detta arrangemang nedbringas härvändspaketets tillväxt med inte mindre än 50%.

I fig. 7 visas en utföringsform av lindningen enligt uppfinningen, kallad trappad slinglindning. Schemat visar lindningen av en fas med kabeln U1. Som framgår börjar kabeln U1 i position 1 i spår 4 för att därefter bilda en härvända till position 2 i spår 11 och därefter bilda den innersta härvan i nästa härvändsgruppdel genom att gå över till position 3 i spår 4 och därefter till position 4 i spår 11 och sedan position 1 i spår 3 för att fortsätta till position 2 i spår 12 och så vidare. Härigenom bildas två härvändsgruppsdelar parallellt med vardera fyra härvor, varvid de fyra härvorna överbryggar sju, nio, elva respektive tretton spår.

I fig. 6 antydes dragningen av kabeln för två härvgruppsdelar i positionerna 1 - 4 i spåren 1 - 4 och 11 - 14.

Genom statorlindningen enligt uppfinningen löses problemet med de stora härvändspaketen, som skulle bli alltför komplicerade med stort antal korsningar, om man tillämpade tidigare känd lindningsteknik i de angivna högspänningsmaskinerna.

Förutom fördelen med den minskade radiella dimen-sionen på härvändspaketen uppstår genom lindningen enligt uppfinningen även hålrum, som på ett fördelaktigt sätt kan utnyttjas för uppstagning av härvändspaketet. Under drift vibrerar nämligen kablarna, och för att undvika nötning mellan dessa krävs uppstagning av kablarna. Oberoende av om dylik uppstagningsanordning användes kan mellan kablarna i härvändspaketen anordnas en tryckfördelande och nötningsförhindrande härdbar massa.

PATENTKRAV

1. Statorlindning i en roterande elektrisk maskin, vilken innefattar en stator (106) försedd med radiella spår (111) för upptagande av en lindning, i lager på olika radiella avstånd från luftgapet (108) mellan rotorn (107) och statorn (106), k ä n n e t e c k n a d av att lindningen är uformad som en kabel varvid den del av en kabeln (101) som sträcker sig fram och tillbaka en gång genom statorn (106) mellan olika lager bildar en härva (113) med en bågformig härvända utskjutande från var ändyta (114) av statorn (106), och att härvorna (113) är uppdelade i härvgruppsdelar och att alla härvor (113) i samma härvgruppsdel är anordnade axiellt den ena utanför den andra med väsentligen sammanfallande centra och med successivt större diametrar, varvid det antal spår (111) som överbryggas av härvorna (113) successivt ökar inom härvgruppsdelen.

2. Statorlindning enligt patentkravet 1, k ä n n e t e c k n a d av att härvorna (113) bildar en formation från luftgapet (108) mot statorryggen (115), genom att kabeln (101) vid övergång från det första spåret till det andra, liksom vid återgång till det första spåret, byter position till närmast utanförliggande lager, tills ett antal positioner i spåret är fyllda för att därefter övergå till närmast liggande spår för att bilda härvor (113), som ligger innanför eller utanför kabeln (101) i de övriga i härvgruppensdelen ingående härvorna (113) i samma formation.

3. Statorlindning enligt patentkravet 1, k ä n n e t e c k n a d av att alla i en härvgruppsdel ingående härvor (113) bildas i en följd av kabeln (101), som först därefter övergår till nästföljande härvgruppsdel för dess bildande.

4. Statorlindning enligt något av patentkravet 1 - 3, k ä n n e t e c k n a d av att antalet härvor (113) i härvgruppsdelen är tre.

5. Statorlindning enligt något av patentkravet 1 - 3, k ä n n e t e c k n a d av att antalet härvor (113) i härvgruppsdelen är fyra.

6. Statorlindning enligt patentkravet 1, k ä n n e t e c k n a d av att härvgruppsdelarna (116, 117) är så inbördes anordnade i omkretsled att varannan härvgruppsdel (116) på sin väg till ett radiellt yttre lager ligger radiellt innanför nästföljande härvgruppsdel (117) och varannan härvgruppsdel (117) radiellt utanför nästföljande härvgruppsdel (116).

7. Statorlindning enligt patentkravet 6, k ä n n e t e c k n a d av att härvorna (113) bildas genom att kabeln (101) vid övergången från ett första spår till ett andra spår, liksom vid återgång till det första spåret, byter position till närmast intilliggande lager, för att därefter övergå till närmast liggande spår och där fylla motsvarande positioner, tills två härvgruppsdelar bildats samtidigt mellan tillhopa fyra positioner i berörda spår, varpå kabeln (101) fortsätter på detta sätt tills dessa positioner fyllts i statorns (106) alla spår (111).

8. Statorlindning enligt något av patentkraven 1 - 7, k ä n n e t e c k n a d av en tryckfördelande och nötningsförhindrande härdbar massa mellan kablarna i härvändspaketen.

9. Roterande elektrisk maskin, k ä n n e t e c k n a d av att den är försedd med en statorlindning enligt något av patentkraven 1 - 8.

10. Roterande elektrisk maskin enligt patentkravet 9, k ä n n e t e c k n a d av att lindningen innefattar en eller flera strömförande ledare (102), kring varje ledare är anordnat ett första skikt (103) med halvledande egenskaper, kring det första skiktet (103) är anordnat ett fast isolerande skikt (104) och kring det isolerande skiktet är anordnat ett andra skikt (105) med halvledande egenskaper.

11. Roterande elektrisk maskin enligt patentkravet 10, k ä n n e t e c k n a d av att det första skiktet (103) är på i huvudsak samma potential som ledaren (102).

12. Roterande elektrisk maskin enligt patentkravet 10 eller 11, k ä n n e t e c k n a d av att det andra skiktet (105) är anordnat på så sätt att det utgör väsentligen en

ekvipotentialyta omslutande ledaren/ledarna.

13. Roterande elektrisk maskin enligt patentkravet 12, k ä n n e t e c k n a d av att det andra skiktet (105) är anslutet till en speciell potential.

14. Roterande elektrisk maskin enligt patentkravet 13, k ä n n e t e c k n a d av att den speciella potentialen är jordpotential.

15. Roterande elektrisk maskin enligt något av patent-kraven 10 - 14, k ä n n e t e c k n a d av att minst två av nämnda skikt har i huvudsak samma värmeutvidgningskoefficient.

16. Roterande elektrisk maskin enligt något av patentkraven 10 - 15, k ä n n e t e c k n a d av att den strömförande ledaren (102) innefattar ett antal kardeler, varvid endast ett fåtal av kardelerna är oisolerade från varandra.

17. Roterande elektrisk maskin enligt något av patentkraven 10 - 17, k ä n n e t e c k n a d av att vartdera av nämnda tre skikt är fast förbundet med intilliggande skikt utmed väsentligen hela angränsningsytan.

18. Roterande elektrisk maskin med magnetkrets för hög spänning där magnetkretsen innefattar en magnetisk kärna och en lindning, k ä n n e t e c k n a d av att lindningen består av en kabel som innefattar en eller flera strömförande ledare (102), varje ledare består av ett antal kardeler, kring varje ledare är anordnat ett inre halvledande skikt (103), kring vilket är anordnat ett isolerande skikt (104) av fast isolation, kring vilket är anordnat ett yttre halvledande skikt (105).

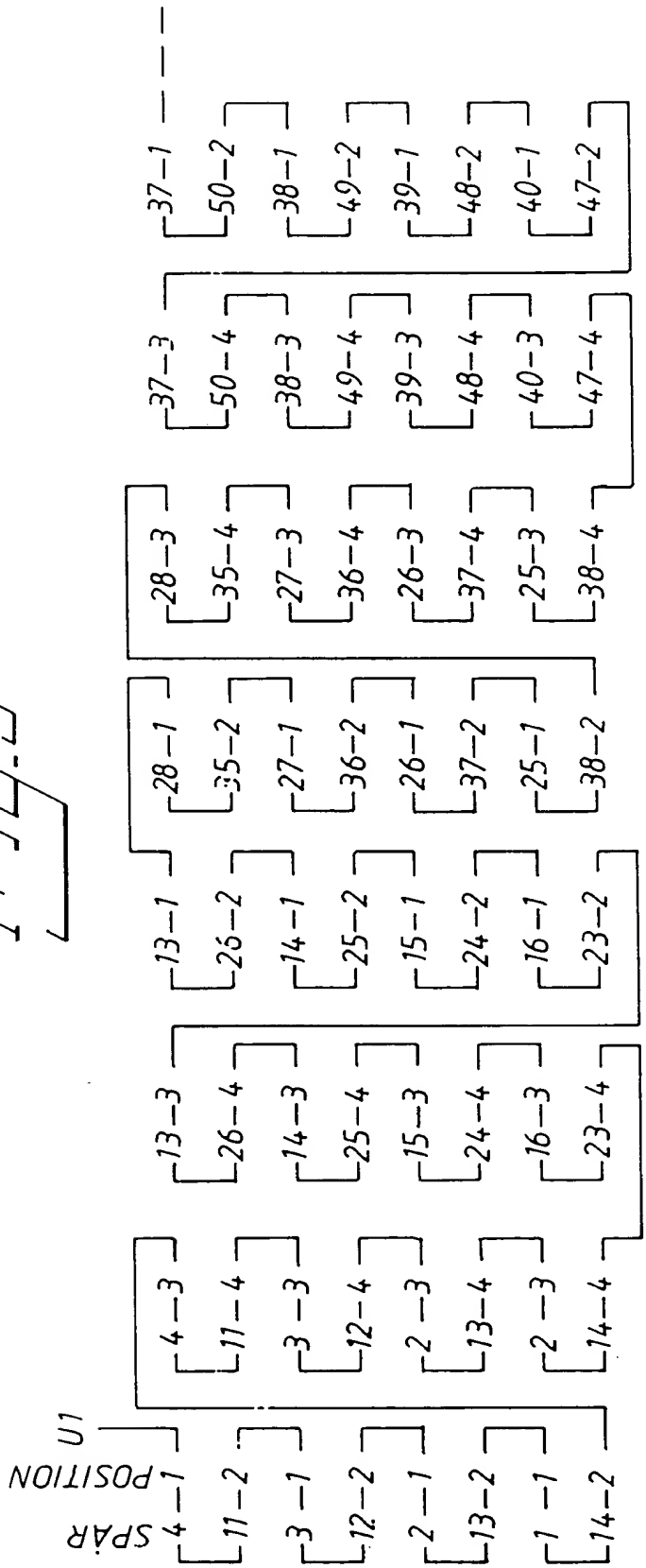
19. Roterande elektrisk maskin med magnetkrets för hög spänning enligt patentkravet 18, k ä n n e t e c k n a d av att kabeln även innefattar en metallskärm och en mantel.

PCT SE 97/00905
27 -05- 1997

SAMMANDRAG

I statorlindningen i en roterande elektrisk maskin upptas lindningens i radiella spår (111) i statorn (106). Lindningen utgöres enligt uppfinningen av en kabel vilken bildar lager på olika radiella avstånd från luftgapet (108) mellan rotorn (107) och statorn (106). Den del av en kabeln (101) som sträcker sig fram och tillbaka en gång genom statorn mellan olika lager bildar en härva (113) med en bågformig härvända utskjutande från var ände (114) av statorn (106). Härvorna (113) är uppdelade i härvgruppsdelar. Alla härvor (113) i samma härvgruppsdel är anordnade axiellt den ena utanför den andra med väsentligligen sammanfallande centra och med successivt större diametrar. Det antal spår (111) som överbryggas av härvorna ökar successivt inom härvgruppsdelen.

(Fig.2)


SPÄR
POSITION
U1
4-1
11-2
3-1
12-2
2-1
13-2
1-1
14-2
4-3
11-4
3-3
12-4
2-3
13-4
2-3
14-4
13-3
26-4
14-3
25-4
15-3
24-4
16-3
23-4
13-1
26-2
14-1
25-2
15-1
24-2
16-1
23-2
28-1
35-2
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36-2
26-1
37-2
25-1
38-2
28-3
35-4
27-3
36-4
26-3
37-4
25-3
38-4
37-3
50-4
38-3
49-4
39-3
48-4
40-3
47-4
37-1
50-2
38-1
49-2
39-1
48-2
40-1
47-2

FIG. 5

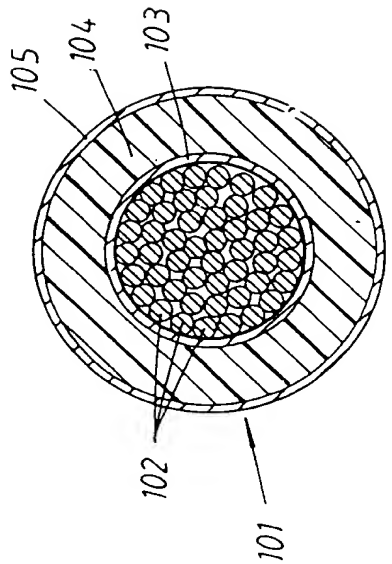

105
104
103
102
101

FIG. 1

Fig. 2

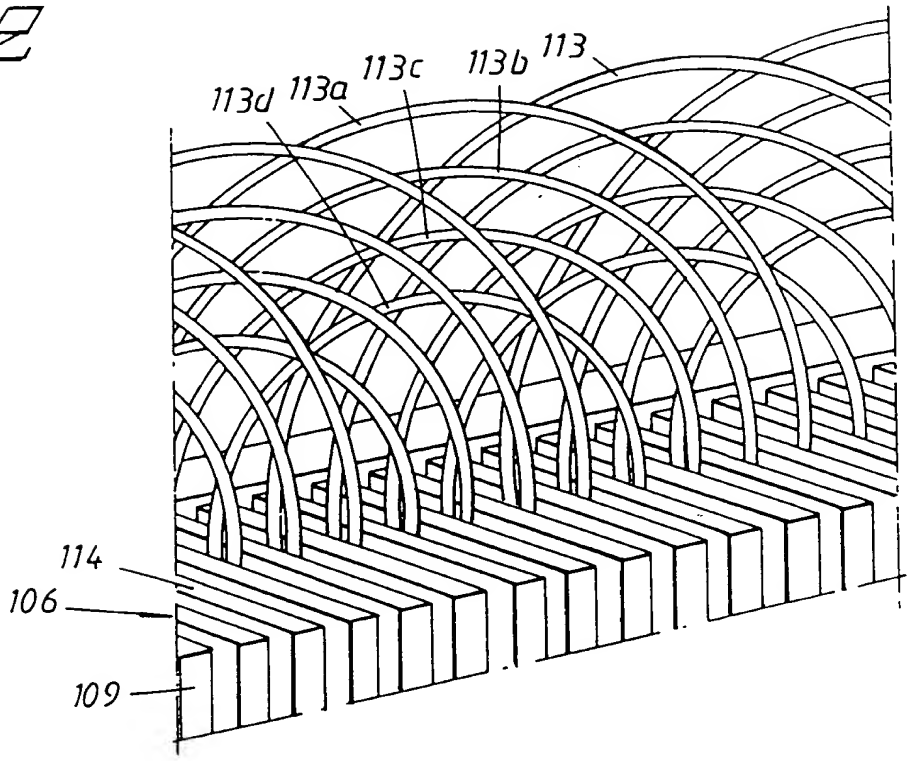
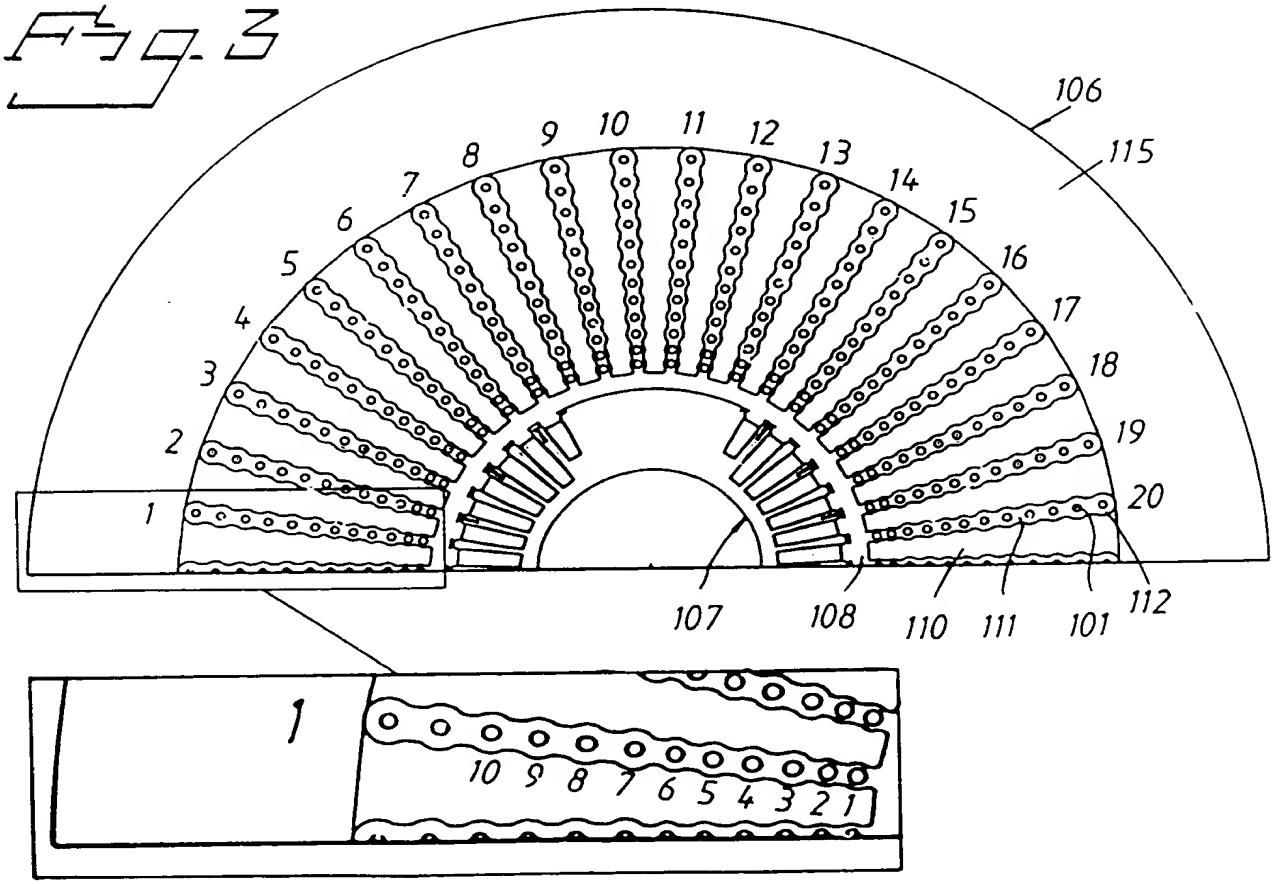

113
113b
113c
113a
113d
114
106
109

Fig. 3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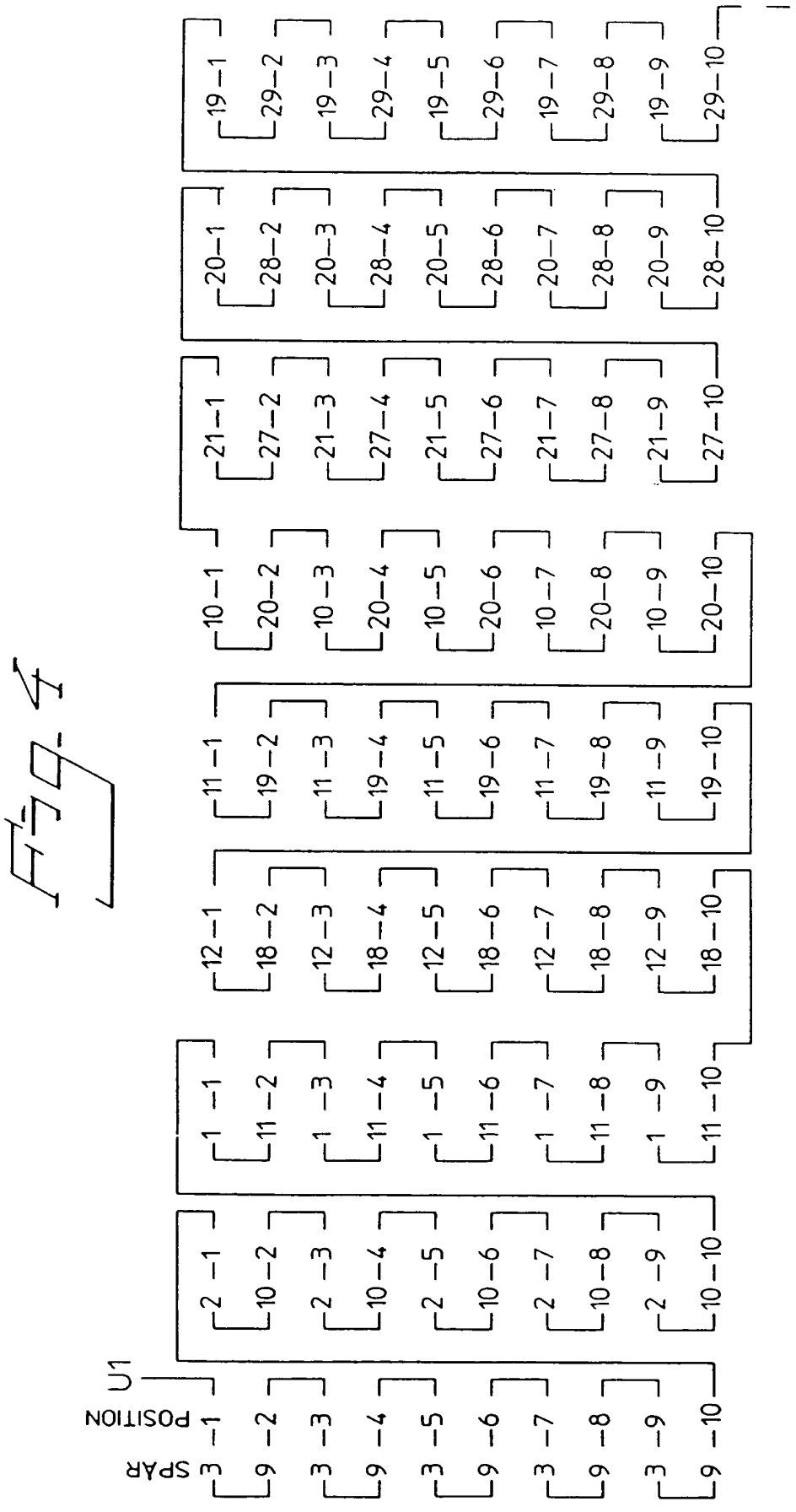
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Fig 4

Fig. 6

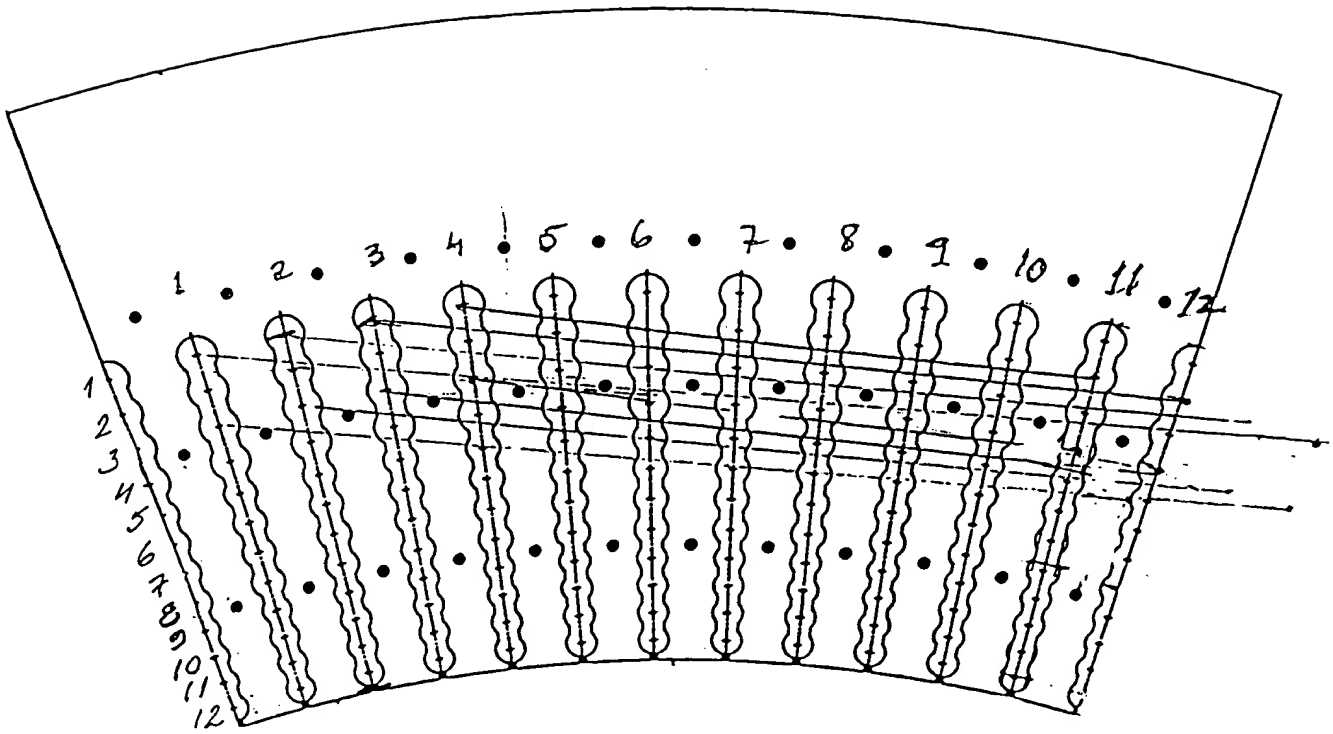


Fig. 7

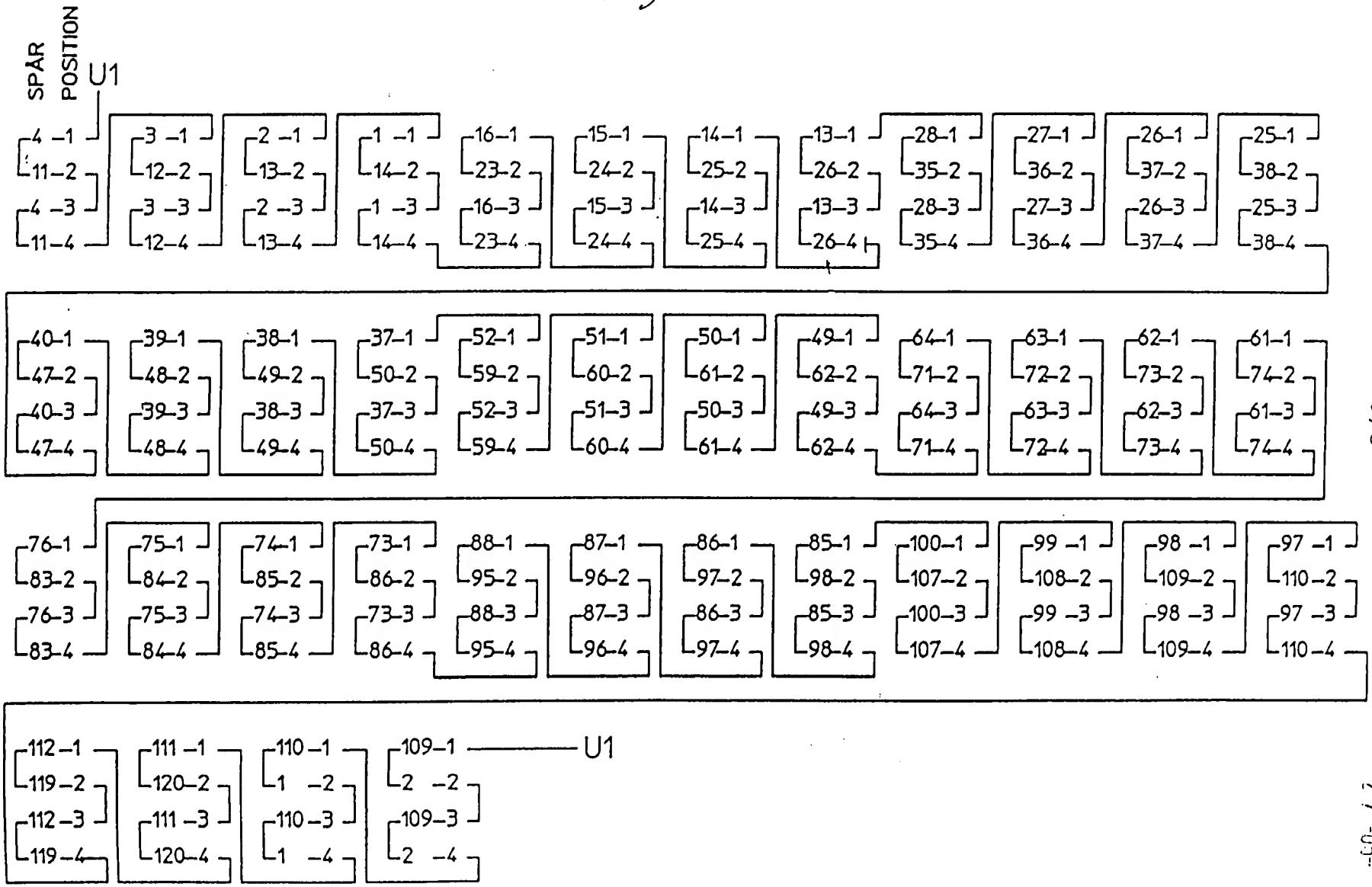
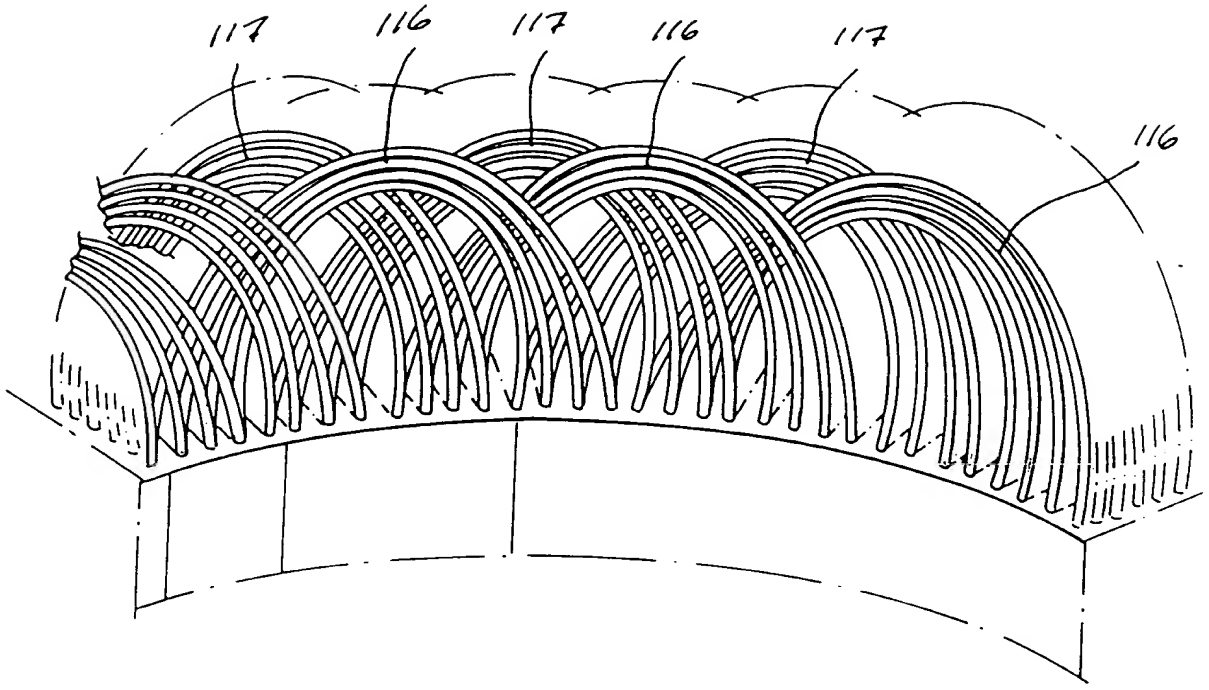


Fig. 8



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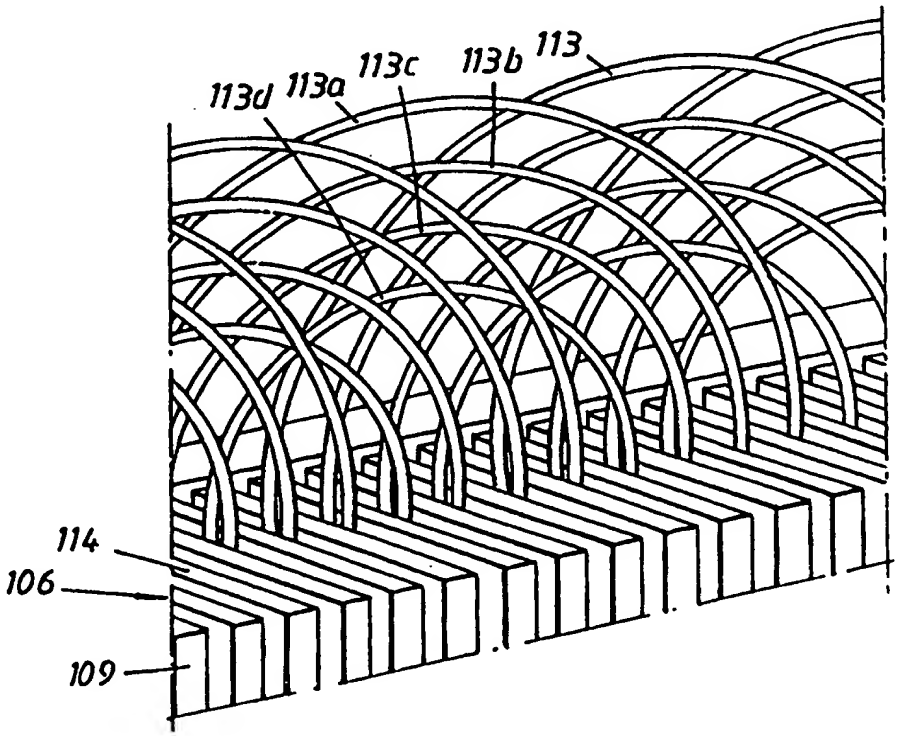
(57) Abstract

In the stator winding in a rotating electric machine the winding is situated in radial slots (111) in the stator (106). According to the invention the winding consists of a cable which forms layers at different radial distances from the air gap (108) between the rotor (107) and the stator (106). The part of the cable (101) that passes to and fro once through the stator between different layers forms a coil (113) with an arc-shaped coil end protruding from each end surface (114) of the stator (106). The coils (113) are divided into coil group parts. All coils (113) in the same coil group part are arranged axially, one outside the other with substantially coinciding centres and with successively increasing diameters. The number of slots (111) that are bridged by the coils (113) successively increases within the coil group part.



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A DEVICE IN THE STATOR OF A ROTATING ELECTRIC MACHINE AND SUCH A MACHINE

The present invention relates to the area of rotating electric machines such as synchronous machines, and also dual-fed machines, applications in asynchronous static current converter cascades, outerpole machines and synchronous flow machines and is intended to be used at high voltages, by which is implied electric voltages in excess of 10 kV. A typical operating range for the machine according to the invention may be from 36 to 800 kV.

The invention relates to a stator winding in a rotating electric machine of the type defined in the preamble to claim 1.

Since the stator winding in the machine, according to the invention, consists of high-voltage insulated electric conductors, in the following termed cables, with permanent insulation similar to that used in cables for transmitting electric power (e.g. PEX cables), the voltage of the machine may be increased to such levels that it may be connected directly to the power network without an intermediate transformer. These voltage levels reaching the level of the power network may be in the range of 130-400 kV and up to 800 kV or higher. This enables the elimination of the step-up transformer and a high-current breaker, thereby enabling lower total plant cost.

It is known to manufacture coils for rotating machines for a voltage range of 10-20 kV.

However, attempts at developing a generator for voltages higher than this have been in progress for some time, as is evident from "Electrical World", October 15 1932, pages 524-525, for instance. This describes how a generator designed by Parson 1929 was constructed for 33 kV. A generator in Langerbrugge, Belgium, is also described which produced a voltage of 36 kV. Although the article also speculates on the possibility of increasing the voltage levels, development of the concepts upon which these generators were based ceased. This was primarily due to deficiencies in the insulating system where several layers of varnish-impregnated mica foil and paper were used.

In A report from the Electric Power Research Institute, EPRI, EL-3391, from April 1984 an exposition is given of the generator concept in which a higher voltage is achieved in an electric generator with the object of being able to connect such a generator to a power network without intermediate transformers. The report deems such a solution to offer satisfactory gains in efficiency and financial advantages. The main reason that in 1984 it was considered possible to start developing generators for direct connection to the power network was that by that time a superconducting rotor had been developed. The considerable excitation capacity of the superconducting field makes it possible to use air-gap windings with sufficient thickness to withstand the electric stresses.

By combining the construction of an excitation circuit together with winding, a so-called "monolith cylinder armature", a concept in which two cylinders of conductors are enclosed in three cylinders of insulation and the whole structure is attached to an iron core without teeth, it was deemed that a rotating electric machine for high voltage could be directly connected to a power network. This solution implied that the main insulation had to be made sufficiently thick to withstand network-to-network and network-to-earth potentials. Besides it requiring a supraconducting rotor, an obvious drawback with the proposed solution is that it requires a very thick insulation, thus increasing the size of the machine. The coil ends must be insulated and cooled with oil or freones in order to direct the large electric fields into the ends. The whole machine is to be hermetically enclosed to prevent the liquid dielectric medium from absorbing moisture from the atmosphere.

All large generators are normally designed with double-layer winding and coils of equal size. Each coil is placed with the one side in one layer and the other side in the other layer. This implies that all coils cross each other at the coil ends. In high-voltage machines the slots in which the coils are placed in the stator are considerably deeper and typically have 10-12 or up to 18, and in certain cases even more winding layers. The number of coil ends is therefore large with many intersections, which complicates the job of winding and may also cause the coil ends to protrude into the air gap between stator and rotor. Another problem is the increased risk of wear at all the intersection points between the coils.

The object of the present invention is to solve the problem of the large coil-end packages and minimize the number of intersections between the winding coils. This object is achieved by the stator winding, according to the invention, being given the features defined in the claims.

The invention is primarily intended for use with a high-voltage cable of the type constructed from a core having a number of strand parts, a semi-conducting layer surrounding the core, an insulating layer surrounding the inner semi-conducting layer and an outer semi-conducting layer surrounding the insulating layer, and its advantages will be particularly noticeable therewith. It relates particularly to such a cable having a diameter within the interval 20-200 mm and a conducting area within the interval 80-3000 mm^2. Such applications of the invention thus constitute preferred embodiments thereof.

The invention is described in more detail with reference to the accompanying drawings in which;

Figure 1 shows a cross -section through a cable used for the invention,

Figure 2 shows a part of one end of a stator having a plurality of coil ends protruding from its surface, only a few of which are included in the drawing,

Figure 3 shows in radial section one half of an alternating current generator with a stator winding according to the invention,

Figure 4 is a schematic diagram of the winding according to one embodiment of the invention,

Figure 5 is a schematic diagram of the winding according to a second embodiment of the invention,

Figure 6 shows one sector of a stator lamination for a winding according to the invention,

Figure 7 shows a schematic diagram of the winding according to a third embodiment of the invention, and

Figure 8 shows a coil-end package seen radially from the air gap, with a winding according to the invention.

Figure 1 shows a cross-sectional view of a cable 101 used for the present invention. The cable 101 comprises a conductor 102 consisting of a number of strands of copper, for instance, and having circular cross section. This conductor 102 is arranged in the middle of the cable 101. Around the conductor 102 is a first semi-conducting layer 103, and around the first semi-conducting layer 103 is an insulating layer 104, e.g. PEX insulation. Around the insulating layer 104 is a second semi-conducting layer 105. In this case, therefore, the cable does not include the outer protective sheath that normally surrounds such cables for power distribution.

Figure 3 shows in a diametric section one half of a high-voltage generator with a stator 106, a rotor 107 and an air gap 108 between them. Figure 2 shows the inner surface 109 of the stator, facing the air gap 108. The stator 106 is provided with inwardly directed stator teeth 110 defining between them radial slots 111 to hold the cables 101 of the winding. The winding thus forms a large number of layers through the deep slots 111, which in the example shown have place for 12 cables in each enlargement 112. "Layer of the winding" in this context refers to layers at different radial distances from the central axis of the stator. "Stratum" on the other hand refers to strata of the winding at different axial distances from the end surfaces of the stator.

It is clear from Figure 2 how the cable 101 forms coils 113 which pass axially to and fro through the stator 106 and form arc-shaped coil ends outside the end surfaces 114 of the stator. A coil thus consists of one turn of the cable through the stator. A coil group comprises the winding for one phase. The part of a coil group situated in one and the same winding layer, and the coil ends of which are situated in different strata is here designated "coil group part".

Contrary to previously known multi-strata stator windings the coils 113 according to the invention are arranged such that they do not cross each other within the same coil group part. Figure 2 shows a group part comprising, in this case, four coils 113a, 113b, 113c and 113d situated axially, one outside the other and with

substantially coinciding centres. Since the coil 113a has a larger diameter than coil 113b, which in turn has a larger diameter than coil 113c, which in turn has a larger diameter than coil 113d, these coils do not cross or touch each other. This implies that the number of slots 111 that each coil bridges before entering the stator again varies within the group part. The coil 113d thus bridges the least number of slots and the coil 113a the largest number of slots.

Winding is also performed so that, upon passage from the first slot in one direction to the second slot in the opposite direction, the cable in the coil changes position in the slot to the nearest winding layer outside it. The same thing occurs when it returns to the first slot. When all positions in the two slots have been filled, the coils produce a formation reminiscent of a spiral compressed from the sides, stretching from the air gap 108 to the stator yoke 115. The cable then passes to the next adjacent slot to form the next coil, inside or outside, in the same formation.

Figure 4 is a schematic diagram showing how the winding of a cable U1 is performed. In Figure 3 the slots 111 and positions therein have been numbered in corresponding manner to Figure 4. Contrary to the example in Figure 2, each coil group part comprises three instead of four coils. According to Figure 4 the cable U1 starts from position 1 in slot 3, changes to position 2 when it reaches slot 9, then to position 3 when it passes back to slot 3 and to position 4 in slot 9, and so on. This continues until all positions in slots 3 and 9 have been filled, whereupon the coils produced in this way together form the above-mentioned formation from the air gap 108 to the stator yoke 115. As is clear, each coil end bridges 9 - 3 = 6 slots. Winding is continued with the construction of a larger external coil in each turn in the formation, through the cable being conducted to position 1 in slot 2, thence to position 2 in slot 10 and back to position 3 in slot 2, and so on until position 10 in slot 10 has been filled. The coil ends here bridge 10 - 2 = 8 slots and the later coils will therefore be situated outside the earlier coils with substantially coinciding centres. The third coil in this group part is formed by the cable passing to position 1 in slot 1, from there to position 2 in slot 11 and then to position 3 in slot 1 and position 4 in slot 11, and so on. In this case the coil ends bridge 11 - 1 = 10 slots and the coils are therefore the largest in the group part and are situated outermost in the spiral. The coil group described forms the winding

for one phase in the generator. The other phases are constructed in similar manner.

Figure 5 shows a second embodiment of the winding according to the invention. Contrary to the embodiment according to Figure 4, the positions 1 and 2 are completely wound in slots 4 and 11, 3 and 12 and 1 and 14, before winding is continued with positions 3 and 4 in the same slots. Winding of these four positions then continues in additional slots. The diagram shows the windings of one phase in a three-phase winding with four coils per slot and four slots per pole and phase.

In the two winding variants described, the number of coils in each coil group part is three and four, respectively. However, the invention is not limited to this, and the number may be anything from two to over ten.

Figures 6-8 show a third embodiment of the winding according to the invention. As can be seen in Figure 6, the positions in the slots have been reversed from those in Figures 3-5 and are numbered radially inwards from the outside. As can be seen in Figure 8, the coil group parts are arranged in relation to each other in peripheral direction such that alternate coil group parts on the way to a layer situated radially further out lie radially inside the next following coil group part and alternate group parts lie radially outside the next following coil group part. Thus, on their way from position 1 in four adjacent slots 111, the coil group parts 116 run radially inside respective adjacent coil groups 117 on their way towards position 2 in four slots 111 bridging seven slots, whereas the coil group parts 117 run radially outside respective adjacently coil group parts 116. This arrangement reduces the growth of the coil end package by no less than 50%.

Figure 7 shows an embodiment of the winding ,according to the invention, known as stepped lap winding. The diagram shows the winding of one phase with the cable U1. As is clear, the cable U1 starts from position 1 in slot 4, forms a coil end to position 2 in slot 11 and then forms the innermost coil in the next coil end group part by passing to position 3 in slot 4, then to position 4 in slot 11, then to position 1 in slot 3, continuing to position 2 in slot 12, and so on. Two coil end group parts are thus formed in parallel, having four coils each, the four coils bridging seven, nine , eleven and thirteen slots, respectively.

Figure 6 indicates the drawing of the cable for two coil group parts in the positions 1 - 4 in slots 1 - 4 and 11 - 14.

The stator winding according to the invention solves the problem of the large coil end package which, if previously known winding technology were used in the high-voltage machines under discussion, would be far too complicated, with a large number of intersections.

Besides the advantage of the reduced radial dimension of the coil end package, the winding according to the invention also provides a cavity which can be beneficially used to hold the coil end package. The cables vibrate during operation, and in order to avoid wear between them they must be reinforced. Regardless of whether such an arrangement is used, a pressure-distributing and wear-preventing curable compound can be used between the cables in the coil.

CLAIMS

1. A stator winding in a rotating electric machine comprising a stator (106) provided with radial slots (111) to hold a winding, in layers at different radial distances from the air gap (108) between the rotor (107) and the stator (106), characterized in that the winding is in the form of a cable wherein the part of the cable (101) that passes to and fro once through the stator (106) between different layers forms a coil (113) with an arc-shaped coil end protruding from each end surface (114) of the stator (106), and in that the coils (113) are divided into coil group parts and that all coils (113) in the same coil group part are arranged axially, one outside the other with substantially coinciding centres and with successively increasing diameters, the number of slots (111) that are bridged by the coils (113) successively increasing within the coil group part.

2. A stator winding as claimed in claim 1, characterized in that the coils (113) produce a formation from the air gap (108) towards the stator yoke (115) since, on passing from the first slot to the second, and also upon returning to the first slot, the cable (101) changes position to the next layer immediately outside until a number of positions in the slot have been filled and then passes to the nearest adjacent slot to form coils (113) that lie inside or outside the cable (101) in the other coils (113) included in the coil group part in the same formation.

3. A stator winding as claimed in claim 1, characterized in that all coils (113) in a coil group part are formed in sequence from the cable (101), the cable only subsequently passing to the next coil group part to produce the latter.

4. A stator winding as claimed in any of claims 1-3, characterized in that the number of coils (113) in the coil group part is three.

5. A stator winding as claimed in any of claims 1-3, characterized in that the number of coils (113) in the coil group parts is four.

6. A stator winding as claimed in claim 1, characterized in that the coil group parts (116, 117) are arranged in relation to each other in peripheral direction such that alternate coil group parts (116) on their way to a radial outer layer are situated radially inside the next following coil group part (117) and alternate coil group parts (117) are situated radially outside the next following coil group part (116).

7. A stator winding as claimed claim 6, characterized in that the coils (113) are formed by the cable (101) on passing from a first slot to a second slot, and also upon returning to the first slot, changing position to the next adjacent layer, and thereafter passing to the nearest adjacent slot and there filling corresponding positions, until two coil group parts have been formed simultaneously between altogether four positions in the relevant slots, whereupon the cable (101) continues in this way until these positions have been filled in all slots (111) of the stator (106).

8. A stator winding as claimed in any of claims 1-7, characterized in that a pressure-distributing and wear-preventing curable compound is provided between the cables in the coil end package.

9. A rotating electric machine, characterized in that it is provided with a stator winding as claimed in any of claims 1-8.

10. A rotating electric machine as claimed in claim 9, characterized in that the winding comprises one or more current-carrying conductors (102), wherein a first layer (103) having semi-conducting properties is arranged around each conductor, a permanently insulating layer (104) is arranged around the first layer (103), and a second layer (105) having semi-conducting properties is arranged around the insulating layer.

11. A rotating electric machine as claimed in claim 10, characterized in that the first layer (103) is at substantially the same potential as the conductor (102).

12. A rotating electric machine as claimed in claim 10 or claim 11, characterized in that the second layer (105) is arranged in such a manner that it constitutes substantially an equipotential surface surrounding the conductor(s).

13. A rotating electric machine as claimed in claim 12, characterized in that the second layer (105) is connected to a special potential.

14. A rotating electric machine as claimed in claim 13, characterized in that the special potential is earth potential.

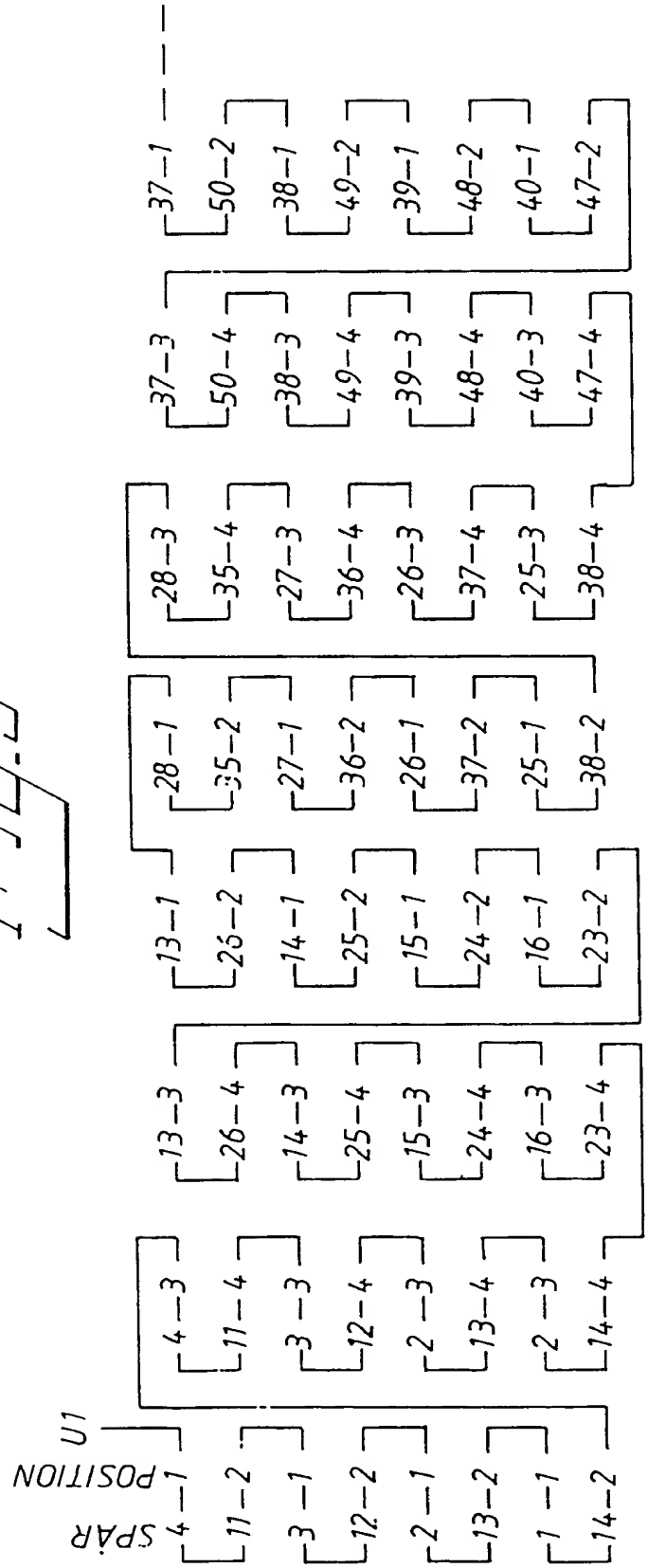
15. A machine as claimed in any of claims 10-14, characterized in that at least two of said layers have substantially the same coefficient of thermal expansion.

16. A rotating electric machine as claimed in any of claims 10-15, characterized in that the current-carrying conductor (102) comprises a number of strand parts, only a few of the strand parts not being insulated from each other.

17. A rotating electric machine as claimed in any of claims 10-16, characterized in that each of said three layers is permanently connected to adjacent layers along essentially its entire continuous surface.

18. A rotating electric machine with a magnetic circuit for high voltage wherein the magnetic circuit comprises a magnetic core and a winding, characterized in that the winding consists of a cable comprising one or more current-carrying conductors (102), each conductor consisting of a number of strand parts, an inner semi-conducting layer (103) being arranged around each conductor, an insulating layer (104) of permanent insulation being arranged around the semi-conducting layer (103), and a semiconducting layer (105) being arranged around the insulating layer.

19. A rotating electric machine with magnetic circuit for high voltage as claimed in claim 18, characterized in that the cable is also provided with metal screening and a sheath.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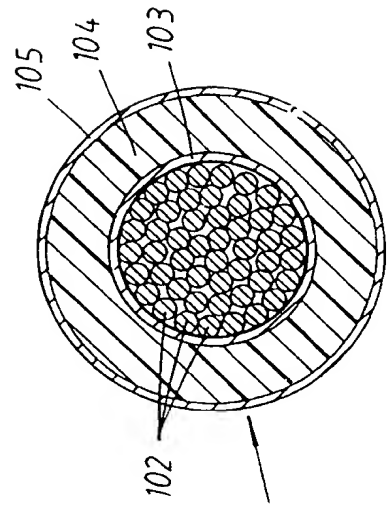
47-2

FIG. 5


105
104
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102
101

FIG. 1

Fig. 2

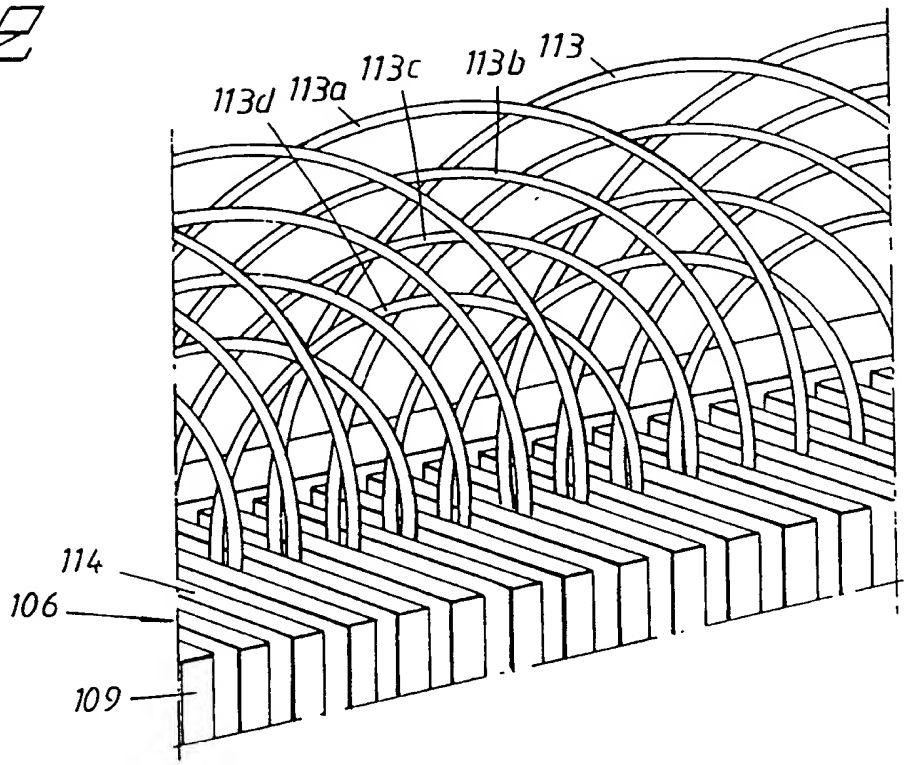
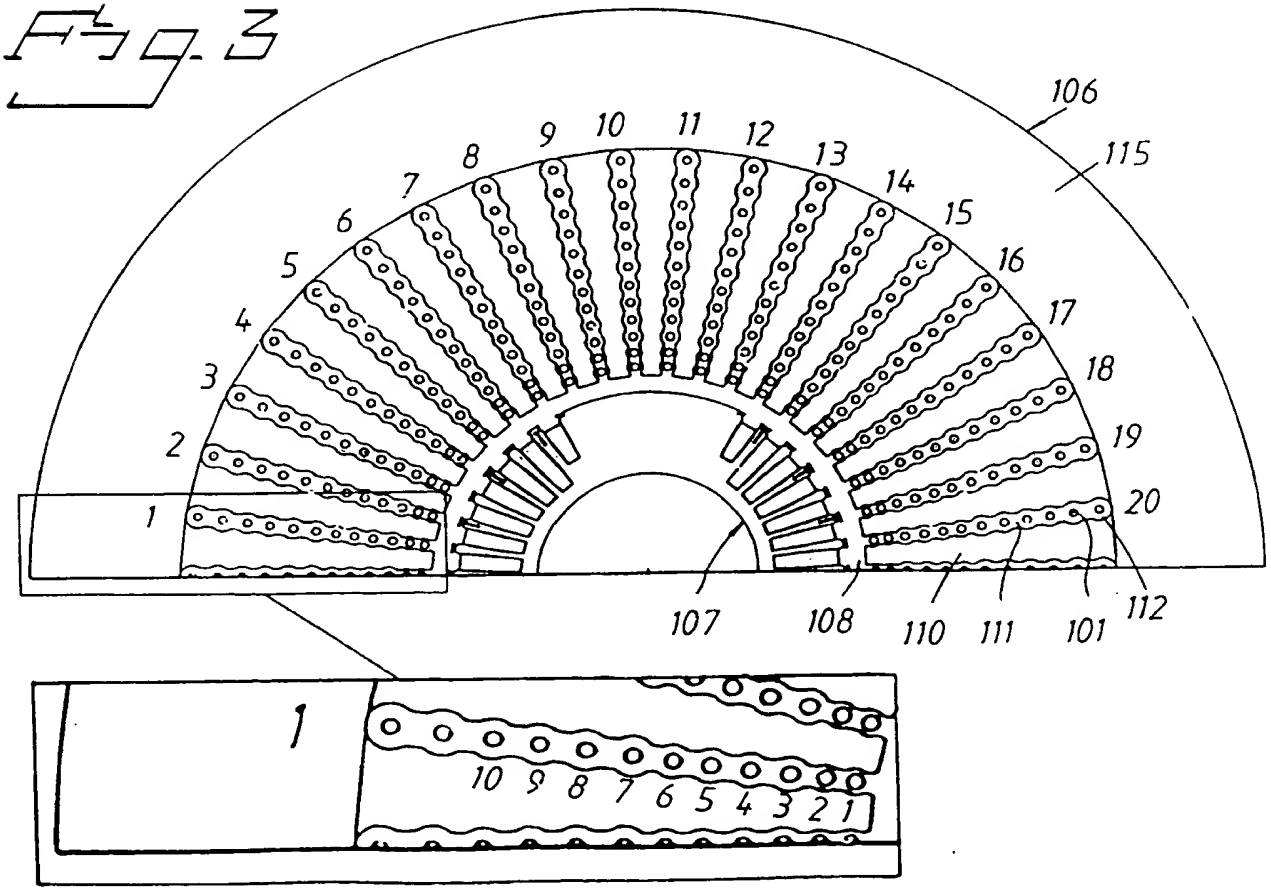

113
113b
113c
113a
113d
114
106
109

Fig. 3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101
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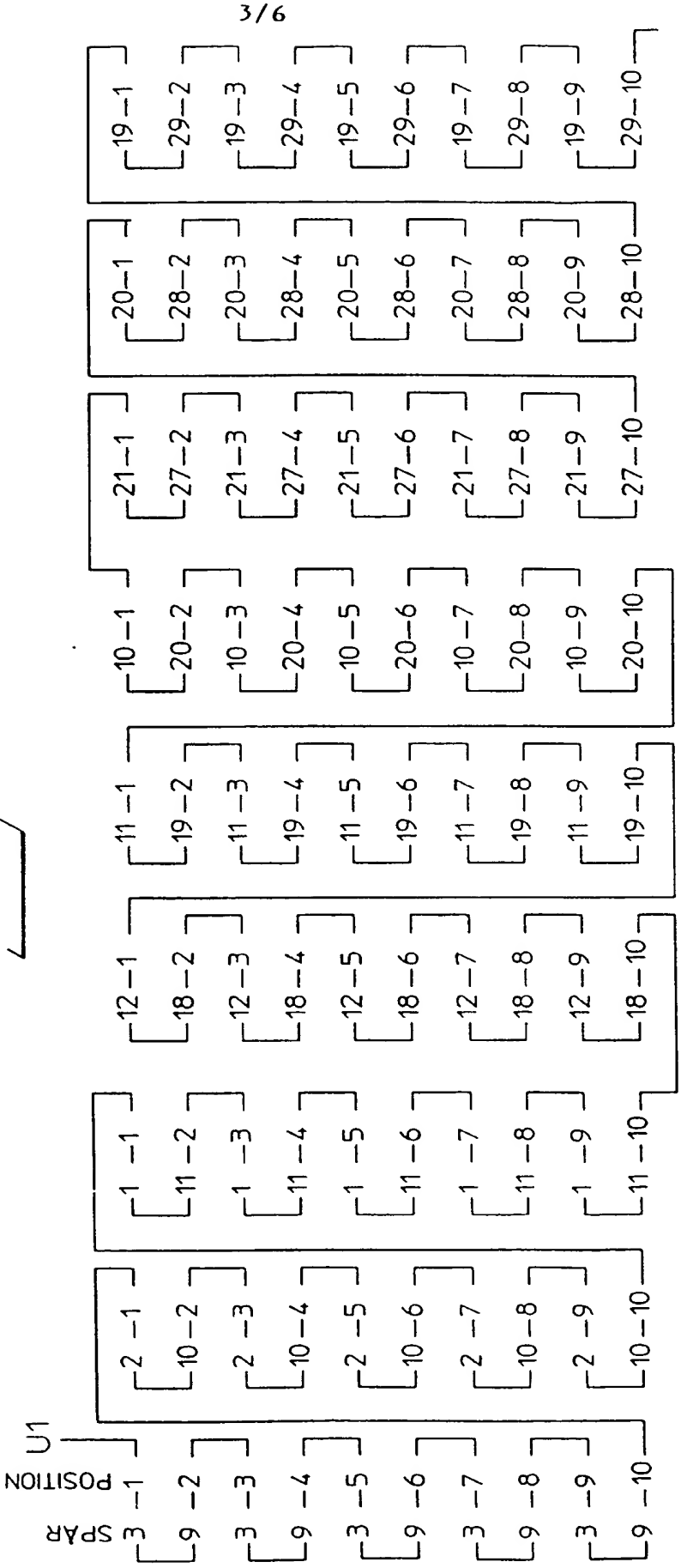
Fig 4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2 -3
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10-8
2 -9
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1 -1
11-2
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Fig. 6

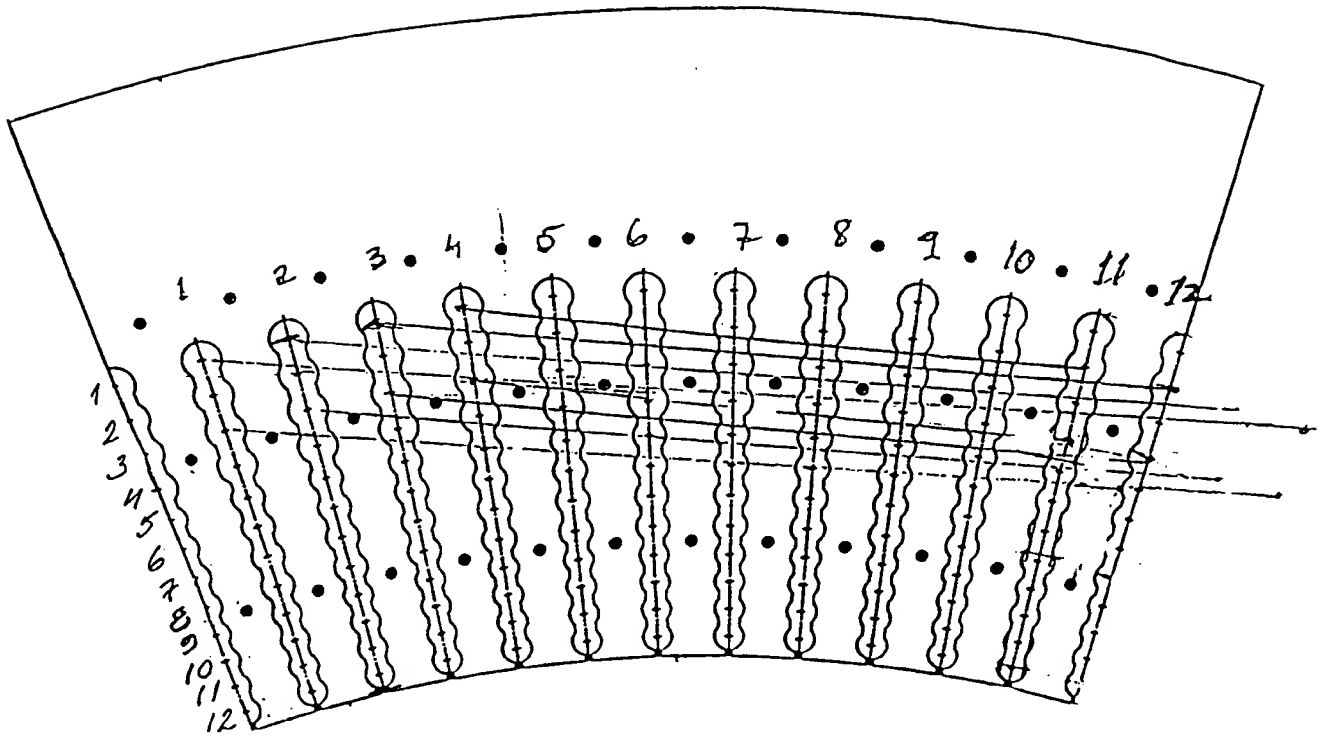
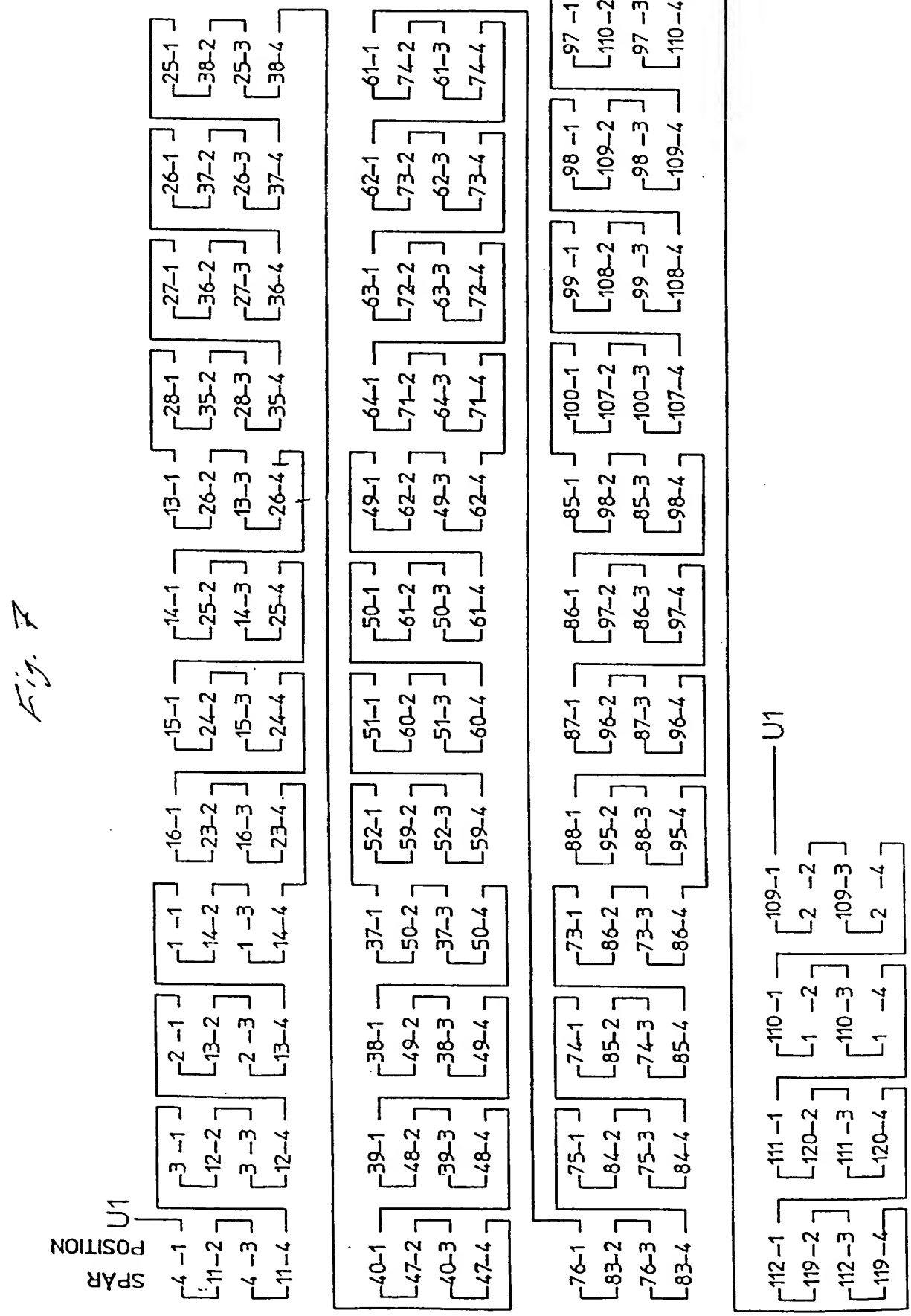


Fig. 7


SPÅR
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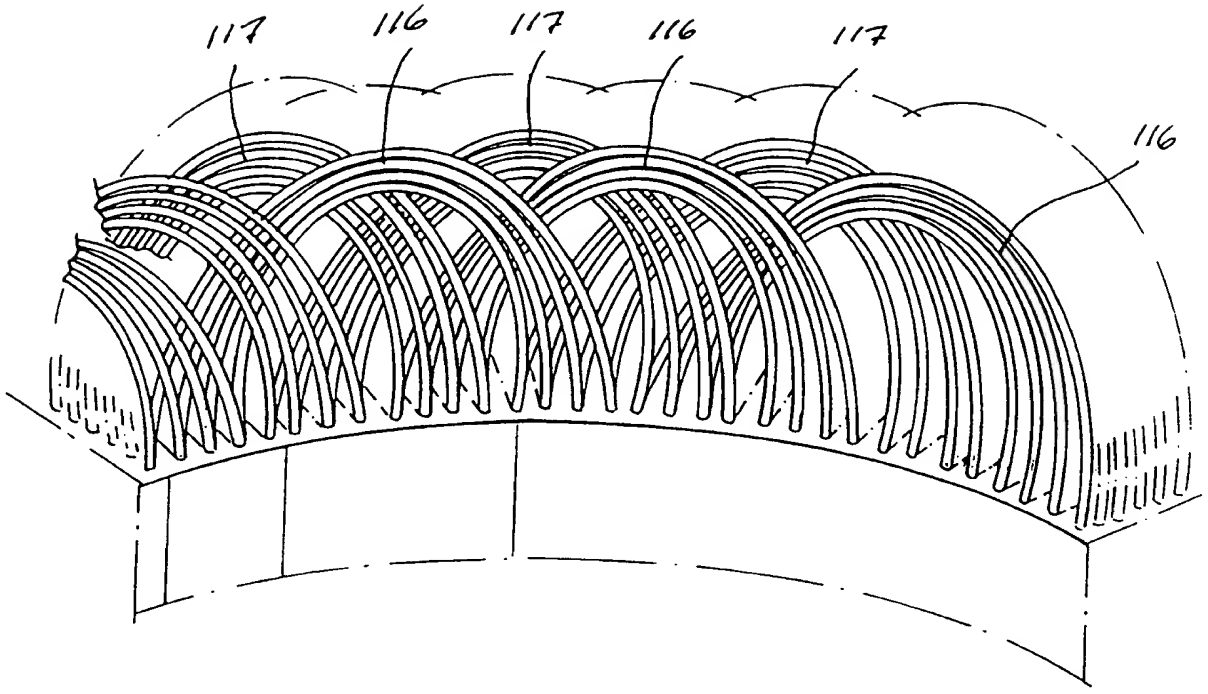
109-3
2 -4
U1

Fig. 8



INTERNATIONAL PRELIMINARY EXAMINATION REPORT

International application No.
PCT/SE97/00905

V. Resoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

1. Statement

Novelty (N)	Claims	1-19	YES
	Claims		NO
Inventive step (IS)	Claims	1-19	YES
	Claims		NO
Industrial applicability (IA)	Claims	1-19	YES
	Claims		NO

2. Citations and explanations

The invention relates to a stator winding in a rotating electrical machine and a rotating electrical machine with a magnetic circuit comprising a winding for high voltage. Said winding is provided with an insulation system comprising two semiconducting layers with solid insulation in-between.

Documents cited in the International Search Report:

(A) US A 5036165
(B) DE A 2155371
(C) DE A 3028777
(D) GB A 2070470
(E) GB A 2106721
(F) WO A 9321681
(G) US A 4307311
(H) US A 4918347
(I) Patent abstract of JP A 59-159642

(A) describes a cable provided with two semiconducting layers with insulation there between.The semiconducting layers include pyrolized organic material and glass fibre. In this document it is suggested that the invented semiconducting layer can be applied to insulated conductors such as a winding in a dynamo-electric machine.

(B-I) relates to general prior art.

The claimed invention differs from the cited art in that the winding of the machine is provided with an insulation system comprising two semiconducting layers with solid insulation in-between.

.../...

Supplemental Box
(To be used when the space in any of the preceding boxes is not sufficient)

Continuation of: V

Even though it is suggested in document A to apply a semiconducting layer to a winding in a dynamo-electric machine there is no specific indication of using the disclosed cable in a dynamo-electric machine. Further investigating US 4853565, incorporated by reference in document A, the skilled person will find it evident that the invented semiconducting layer is intended to be used on a conventional winding in a machine or in a cable. There is no proposal to use the cable with the insulating system as a winding in an electric machine. Nor can it be considered obvious to a person skilled in the art to use such a cable in a dynamo-electric machine since at the time of the invention it was not known to use a cable with solid insulation as a winding in an electrical machine and there is no teaching in the prior art as a whole that would lead the skilled person to the claimed invention.

Accordingly, the invention claimed is novel and involves an inventive step. The invention is industrially applicable.